Development of HSE MS tool base on Shell Malaysia Trading oil depot operations

by

Mohd Fadzli Bin Mohd Puat

Dissertation Report submitted in partial fulfillment of
The requirements for the
Bachelor of Engineering (Hons)
(Chemical Engineering)

January 2004

Universiti Teknologi PETRONAS
Bandar Seri Iskandar
31750 Tronoh
Perak Darul Ridzuan

CERTIFICATION OF APPROVAL

Development of HSE MS tool
based on Shell Malaysia Trading oil depot operations

by

Mohd Fadzli Bin Mohd Puat

A project dissertation submitted to the
Chemical Engineering Programme
Universiti Teknologi PETRONAS
In partial fulfillment of the requirement for the
BACHELOR OF ENGINEERING (Hons)
(CHEMICAL ENGINEERING)

Approved by,

____

(Pn. Risza Rusli)
Main Supervisor

UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK
January 2004

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

MOHD FADZLI MOHD PUAT

ACKNOWLEDGEMENT

The author would like to express the deepest gratitude and appreciation to the supervisor, Mrs. Risza Rusli for all the support and guidance within the period of completing Final Year Project (ECB 5034). Not forgetting, Mrs.Anis Suhaila Shuib for coordinating the subject smoothly.

The author admiration and gratification then goes to Mr. Jaafar Rahman, Shell Malaysia Trading Distribution HSSE Advisor for his co operation and permission to allow utilization of Bagan Luar oil depot as basis for this study. His guidance and opinion has also contributed much to the development of this study. Thank you also to Mr. Arzumi Hussin and Mr. Fadzril Muhammad, for lending their thoughts, knowledge and experience in instilling Information Technology aspect to this study.

To others who involve either direct or indirectly in this project, the author feels really grateful for everything. On the whole, a single page acknowledgement is absolutely not enough to show author's sincere gratefulness, love and respect to all of the people who has helped to accomplish the project.

TABLE OF CONTENTS

ABSTRACT

HSE is a compulsory aspect to be considered in any industry and even process for that matter. Various accidents and disasters have occurred due to negligence of HSE aspect. Few of the major ones are the Alpha Piper incident, Union Charbide Bhopal incident and the Longford incident HSE MS is the synergy of health, safety and environment aspect of industry. The implementation of HSE MS as structured set of controls for managing HSE; will ensure and to demonstrate the HSE objectives set in the policy are met. The purpose of this report is to represent the final output of study on Development of HSE MS tool base on Shell Malaysia Trading Bagan Luar oil depot operations. This HSE MS tool can also be define as information management model for HSE data. This paper presents the project focusing on the problem statement and the objective as well as the scope of study. It also covers the analytical review of written materials HSE MS and the methodology that will be used in completing this project. The result and discussion of this project is also touched in this report. There is also an insight of conclusion and recommendations for this project.

LIST OF FIGURES

LIST OF TABLES

ABBREVIATIONS

ALARP – As Low As Reasonably Possible

ASP – Active Server Page

DOE – Department of Environment

DOSH – Department of Occupational Safety and Health

EMS – Environmental Management System

EQA 74 – Environmental Quality Act 1974

ERP – Emergency Response and Preparedness

ETA – Event Tree Analysis

FTA – Fault Tree Analysis

FYP – Final Year Project

HEMP – Hazards Effects Management Process

HSE – Health, Safety and Environment

HSE MS - Health, Safety and Environment Management System

IIS – Internet Information Services

KPI – Key Performance Indicator

LAN – Local Area Network

MHMS – Minimum Health Management Standard

MIS – Management Information System

OSHA 94 – Occupational Safety and Health Act 1994

PTW – Permit To Work

RAM – Risk Assessment Matrix

SD – Sustainable Development

UTP – Universiti Teknologi Petronas

WAN – Wide Area Network

CHAPTER 1.0
INTRODUCTION

1.1 Background of Study

HSE is a grave issue in any industry. It is a responsible that must be adhered by all industrial practitioners. Various accidents and disasters have occurred due to negligence of HSE aspect. Few of the major ones are the Alpha Piper incident, Union Charbide Bhopal incident and the Longford incident. The need of a proper HSE MS was the major finding from the investigation of Alpha Piper incident by Lord Cullen Committee. Advancement of information technology beckons the need to enhance HSE MS to adapt to the current information wave. Nowadays, industrial practitioners develop HSE MS that fulfill legal requirements and the system is usually certified. The HSE MS are usually documented as hard copy for reference and inter connected through the organization's intranet. Few examples of currently practiced HSE MS are Shell's HSSE MS and also Petronas HSE MS known as Petronas Technical Standard. The current system is not comprehensive in the sense that the HSE elements are not compiled together in the HSE MS The challenge of this study is to link the HSE elements in the HSE MS in a LAN environment within the facility and make it a operational system whereby users can easily launch the HSE MS tool from the comfort of their desktop. This study will utilize current available HSE MS that adheres to local legislation and international certified standards practiced by Shell Malaysia Trading and high-level language computer software to create an interface for HSE MS that is easily navigated and available on desktops. This will ensure industries have an effective and continuously exercised HSE MS and evolve HSE MS itself.

1.2 Problem Statement

Law and regulations on occupational safety and health and environment continue to be more stringent due to boost of public awareness and knowledge of future consequences. The current competitive market drives industrial practitioners to adopt Sustainable Development (SD) concept to build a competitive and sustainable business by vying for certification. The certification will boost the reputation of the business entity and project it as a good corporate citizen. The answer to all of the problems identified above is implementation of a HSE MS. HSE MS is modeled through international certified standards such as ISO 14001 and ISO 18001 and also local law and regulations. HSE MS main feature is to maintain all hazards of operation or activities at ALARP. Furthermore, HSE MS can also avoid future complications during decommissioning, legal acts and audits. Current practice HSE MS are usually documented as hard copy for reference and inter connected through the organization's intranet. Therefore, the system is more manual oriented rather than practice oriented and requires major human participation. Complications on documentation such as misplace of records and data due to human failure and inefficiency will result in impairment of HSE MS and defeat its main purpose. The HSE elements are also not synergize in HSE MS in a sense that current HSE MS encompasses only on the procedure but not on the practice. A classic example is that HSE MS mentions the need to maintain hazard at ALARP but it doesn't provide the tools on how to execute this need.

This research will study the possible evolution of HSE MS by creating it as tool or simple interactive software applicable to be use on computers and tackle all the above mentioned problems on documentation. This study introduces a new concept of integrating HSE elements in HSE MS as an added value to current practice. The significant of this study is the end product will be a marketable product that can be utilize by industrial practitioners. The end product is a HSE MS tool that can be applied and continuously exercised on computers. This will enable wider personnel coverage and a more transparent system in managing HSE issues that can be objectively audited.

1.3 Objective Of Study

The purpose of this study is to develop a marketable and functional HSE MS tool base on Bagan Luar oil depot operations.

This tool would be HSE MS software for operations of the depot in maintaining hazards at ALARP.

To demonstrate the concept of integrating HSE elements and HSE MS components in HSE MS tool.

To develop HSE MS tool for application of Bagan Luar oil depot in Penang.

To avoid disastrous tragedy by reducing human failure by managing HSE data through HSE MS tool.

To cultivate safety and HSE culture by participation of personnel.

1.4 Scope of Study.

This study will encompass on the objective to develop a HSE MS. Current HSE MS are exposed to two major weaknesses which are mismanagement of data and also non inclusive of HSE elements and tools. This will ensure main objective of HSE to manage hazards at ALARP is achieved. This study will develop a tool that will integrate HSE elements and tools that will be explored in latter stages of this report. The final output of this study will be HSE MS tool that has marketable and functional for industry.

This study will be conducted on case study basis. The identified participant in this study is Shell Malaysia Trading Distribution depot at Bagan Luar, Penang. The final output will not only enhance HSE performance of the depot, maintain hazards at ALARP but also will assist depot operations and act as a training kit for external parties from the depot. This scope of this research project is feasible with the available resources. The resources emphasize here are time, information, collaboration with external parties and finance. The project time frame is presented in Appendix 1. This project is a win-win situation whereby it satisfies the external party as well as UTP requirements for FYP.

CHAPTER 2.0

LITERATURE REVIEW AND THEORY

2.1 HSE MS

Management System is a structured set of controls for managing the business; to ensure and to demonstrate that business objectives are met. HSE MS is a structured set of controls for managing HSE; to ensure and to demonstrate the HSE objectives set in the policy are met. HSE is important to control risk and demonstrate ability to control risk of the industry at ALARP. HSE MS can also improve performance and ensure compliance to legal requirements. HSE MS can also make the industry more appalling through international standards certification. It is well documented that public awareness on HSE issues is on the rise and multinational companies prefer to be associated with business entities with certification. HSE MS can also help prevent repetition of past incidents and disasters such as Alpha Piper Incident, Union Charbide Bhopal incident and also Longford incident.

A classic example of inefficient HSE MS is the Longford incident. A major explosion at the Longford gas refinery in Australia resulted in 2 deaths and 8 injuries. The refinery met 95% of Victoria's gas needs. The hiatus in supply led to power shortages. The power shortages led to considerable pressure from many stakeholders. Business implications and reputation was severely threatened and there was a risk that cross-border competitors could dent Esso's market share. The investigation findings redirect the cause to weakness in documentation and records. This is the current weakness in current HSE MS as mentioned in earlier section. This study will tackle this weakness.

HSE MS is the synergy between health, safety and environment matters for the industry. It governs all the above-mentioned laws and international standards. Therefore, HSE MS is a must for any industry in order to even initiate their business. General HSE MS model is attached in figure below.

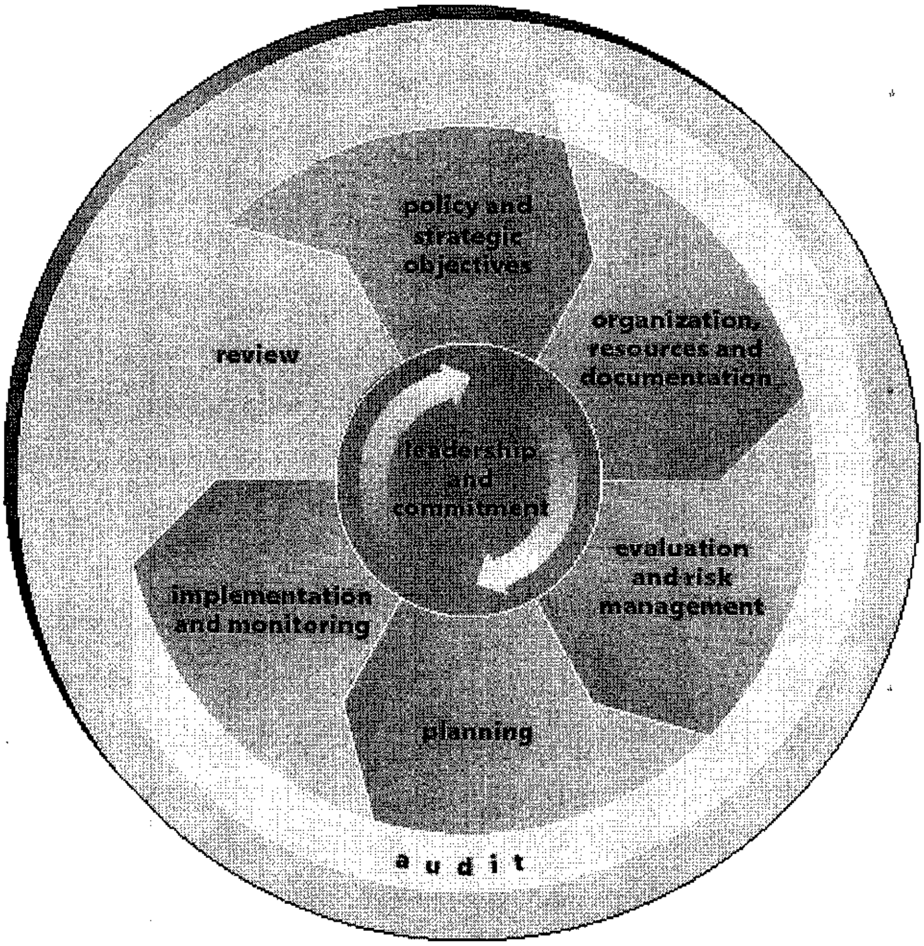


Figure 1: HSE MS Model

The example of controls in HSE MS refers to controls through leadership and commitment, organization, policy, task and responsibilities, law and authority, standards, procedure and work instructions, performance measurements, audits, management review and appraisal.

Team leaders or management level should be fully committed to achieving the objectives of the HSE MS, and providing a leading role for all depot personnel and contractors by encouraging: Belief: in the company's commitment to improve HSE performance. Motivation: to improve personal HSE performance. Participation: of staff at all levels in working to achieve excellent HSSE performance. This are controls through leadership and commitment.

Organization and allocation of task and responsibilities enable optimization of resources in enabling implementation of an effective HSE MS. Through these control measures personnel can work as a unit and together manage HSE issues.

Policy is the goal or objective or plan. Therefore it is an important control in managing HSE. Below is a sample of HSE policy for a multinational company. The presence of this policy acts a guideline for personnel in managing HSE.

have a systematic approach to HSSE management designed to ensure compliance with the law and to achieve continuous performance improvement;

set targets for improvement and measures, appraise and report performance;

require contractors to manage HSSE in line with this policy;

require joint ventures under our operational control to apply this policy and use our influence to promote it in its other ventures;

include HSSE performance in the appraisal of all staff and reward accordingly.

Law and authority is the best route in controlling any activity including HSE. Environmental Quality Act 1974 (EQA) is the law that regulates environmental aspect while Occupational Safety and Health 1994 (OSHA) protect safety and health of personnel. Both these laws also protect the interest of third party. Department of

Environment (DOE) and Department of Occupational Safety and Health (DOSH) are the bodies held accountable to ensure the laws are abide.

There are available standards on HSE aspect which are applied in business on voluntary basis. ISO 18001 is the international standard certification for occupational health and ISO 9000 is the international standard certification for safety.1S0 14001 is the international standard certification for environmental management system. Environmental Management Systems (EMS) have been in existence since the 1970s. Their development was associated with the tightening of legislation which placed additional responsibilities on industry to reduce its impact on the environment. An Environmental Management System serves to link the different processes and business units of which all organisations are comprised, in order to assist organisations to achieve environmental goals. This ensures potential adverse environmental impacts are dealt with proactively. The requirements of ISO 14001 are summarised in the flowchart below:

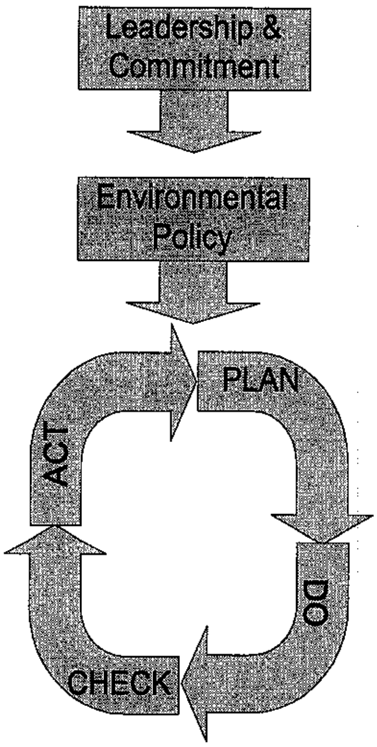


Figure 2: ISO 14001 elements flowchart

Leadership and commitment is essential for the successful implementation of a Management System of any type. It is important that this element of the EMS is in place prior to the implementation of subsequent stages.

Environmental Policy defines the organisation's intent in terms of the environment .EMS ultimately aim to implement the intentions stated in the Policy .
Plan is identifying the requirements of ISO 14001 and planning and organising system implementation. involves identifying the environmental impacts associated with the organisation, legislative requirements, setting environmental objectives and planning their means of achievement

Business and organization do apply controls of HSE aspect through motivation. Performance measurements, audits, management review and appraisal are means of motivation. Personnel are rewarded accordingly through appraisal and performance measurement. Therefore, they will strive to achieve all policy set for HSE. Audit and management review are tools or controls to ensure HSE MS or controls set are followed.

2.2 HSE Tools

The ultimate goal of HSE is to maintain all hazards and risk at ALARP. There are various available tools to achieve this objective. Selected tools will be applied in integrating HSE elements in HSE MS to develop the HSE MS tool for this project. Below is the summary of available tools or aids:

2.2.1 ASPIN

ASPIN provide an easy-to-use quantitative failure risk assessment tool to compare different options and conditions during pipeline design and operation and to assist in optimising and planning inspection and maintenance efforts.

Leadership and commitment is essential for the successful implementation of a Management System of any type. It is important that this element of the EMS is in place prior to the implementation of subsequent stages.

Environmental Policy defines the organisation's intent in terms of the environment .EMS ultimately aim to implement the intentions stated in the Policy.
Plan is identifying the requirements of ISO 14001 and planning and organising system implementation. involves identifying the environmental impacts associated with the organisation, legislative requirements, setting environmental objectives and planning their means of achievement

Business and organization do apply controls of HSE aspect through motivation. Performance measurements, audits, management review and appraisal are means of motivation. Personnel are rewarded accordingly through appraisal and performance measurement. Therefore, they will strive to achieve all policy set for HSE. Audit and management review are tools or controls to ensure HSE MS or controls set are followed.

2.2 HSE Tools

The ultimate goal of HSE is to maintain all hazards and risk at ALARP. There are various available tools to achieve this objective. Selected tools will be applied in integrating HSE elements in HSE MS to develop the HSE MS tool for this project. Below is the summary of available tools or aids:

2.2.1 ASPIN

ASPIN provide an easy-to-use quantitative failure risk assessment tool to compare different options and conditions during pipeline design and operation and to assist in optimising and planning inspection and maintenance efforts.

It is a tool that is situated between a full Quantitative Risk Assessment (QRA) and simple risk ranking/scoring methods, less complicated and expensive than the former and more quantitative (and therefore more accurate) than the latter. It is intended as a decision support tool and does not specify acceptance criteria for risk levels. It can, for example, identify the effect of use of inspection pigging and a leak detection system on risk levels.

The methodology is based on the generally applied risk analysis technique whereby the probability of a failure, expressed in terms of expected failure frequency, is multiplied by the consequence of such a failure to arrive at risk. Failure risk is determined cumulatively over a given longer period of time as well as on a yearly basis. The method is structured in four main parts:

a. Identify the possible failure causes and derive potential failure frequencies

b. Identify the most likely failure type distribution

c. Identify the consequences of pipeline failure

d. Combine parts 1 and 3 to derive risk levels

Information required or input required to use this tool are:

pipeline fluids (those covered are: crude oil, natural gas, sour natural gas, NGL, fuel gas, gas oil/diesel, kerosene/naphtha/gasoline, LPG, ethylene, propylene and two-phase oil/gas fluids)

impact failure statistics and failure frequencies

construction/material defect failure statistics and failure frequencies

corrosion statistics or estimated possible mechanisms/expected time to first failure (wall thickness, critical defect depth, inspection surveys, actual corrosion data), annual corrosion failure frequencies

Outputs from this tool are safety, environmental and economic risk comparison assessments that can be used in support of pipeline design and operation decisions.

ASPIN can be used in the development of HSE Cases as part of the HSE MS including input into Hazards and Effects Register. ASPIN identifies and assesses all potential major hazards, evaluates the risks and the effectiveness of the various measures to reduce the risks to the lowest practicable level.

2.2.2 Emergency Systems Survivability Analysis (ESSA)

This to is use in determination of the ability of the emergency systems to withstand severe accident conditions. If performance criteria for essential safety systems are developed as part of the process which evaluates fires and explosions an ESSA as a separate exercise may not be required.

The process includes identification of all the safety and emergency systems. Assessment of the criticality of each system with respect to preventing escalation, protecting the Temporary Refuge(s) (TR(s)) and enabling escape/evacuation. The critical systems are then assessed to determine their vulnerability to explosions and fires.

This tool requires detailed information on the type and layout of safety and emergency systems for example ESD power systems and emergency communications. Fire and explosion scenario data from the Explosion Protection Review (EPR) and Fire and Explosion Analysis (FEA) .

This tool will deliver identification of critical emergency equipment and system locations and assessment of the vulnerability of the critical systems during direct and escalated events.

2.2.3 Environmental Assessment (EA)

EA predict the significant chemical, biological and socio-economic effects of an activity and to make recommendations on activities, sites, techniques and technologies to be adopted in order to maximise the positive, and minimise the negative effects.

EA is conducted sustematically using these methods:

a. Acquisition of environmental description in terms of abiotic, biotic and human environments

b. Identify project environmental hazards and characterise the environment

c. Evaluate the magnitude and significance of environmental effects

d. Determination of any environmental control and recovery management requirements

Information on site and potential waste product descriptions, project description including process materials and sources, materials of construction, project schedule and both strategic and local economic benefits.

EA will provide an Environmental Statement and also mitigation and recovery measures during operations Environmental report covering suggested monitoring programmes and environmental management systems will be the final output. This report can be used as the basis for public meetings and exhibitions if required.

2.2.4 Fire and Explosion Analysis (FEA)

FEA is a general term for a process which identifies and evaluates all fire and explosion hazardous events as a basis for risk reduction and for preparing performance criteria for essential safety systems and the arrangements required for Escape, Evacuation and Rescue (EER).

The location and type of all potential fires (and explosions) are identified. The capability of the existing or required fire protection (and explosion relief) measures are established together with the corresponding performance standards. Estimates of the damage potential of each event are made. The FEA process is a fundamental part of developing an installation Quantitative Risk Assessment (QRA) model and can either be undertaken as part of the QRA or as a stand alone exercise providing input to the QRA.

Detailed information on plant layout, fire areas, hazardous areas, flammable inventories, fire and safety equipment layout, passive fire protection location, fire water piping runs and any other pertinent data are required for implementation of this tool.

All potential fire and explosion events are identified and a number subjected to more detailed evaluation. Requirements for the essential safety systems to manage fire and explosions and for EER are identified.

2.2.5 FIREPRAN

FIREPRAN is a structured review technique for the review and assessment of:

a. hydrocarbon release and combustion related risks in a facility

b. the fire and explosion control and recovery preparedness measures in place.

c. the capability to meet the performance standards set and satisfy the objectives and criteria set for the management of fire and explosion hazards.

FIREPRAN will identify deficiencies and opportunities for improvement in order to meet objectives with respect to fire and explosion management. FIREPRAN is not suited to complex, compact integrated facilities.

A multi-disciplined team uses a structured HEMP compatible approach to identify hazards related to hydrocarbon releases and explosions and develops a hazards and effects hierarchy. The hazard control measures and related hazardous events mitigation and recovery measures are recorded in a hazards and effects register. Potential fire and explosion scenarios are developed enabling review of the resources needed to respond effectively to these incidents. Resources needed to respond effectively to fire and explosion hazardous event scenarios are compared with those already in place. Results are presented with opportunities for improved risk reduction measures as appropriate to plant criticality.

There are 3 major requirements for FIREPRAN. Process flow schemes, plot plans, plant layouts and hazardous area drawings Fire system and fire water piping drawings, fire areas, equipment layout, fire and blast walls and passive fire protection drawings Operating and maintenance philosophies

This technique permits the identification of hazards as well as potential, related fire and explosion scenarios. It assists line management in the process of developing realistic, cost effective, control and recovery measures which can be justified in terms of reducing risks to personnel, environment, assets and production, to tolerable levels. Deliverables take the form of a hazards and effects register, fire and explosion scenario development sheets and a set of recommendations for actions needed to achieve tolerable risk levels.

2.2.6 HAZID (Hazard Identification)

HAZID is a technique to identify at an early stage in a green or brown field project or development plan the major Hazards which must be removed or managed. A multi-disciplined team review of the overall project development proposal (including infrastructure) plant design and operation together with its impact on the local environment. The study uses a step-by-step methodology and a checklist of guide words to identify hazards and assess the influence these hazards may have on the project development strategy and design philosophy. The scope will encompass both current and future life cycle issues.

HAZID process requires Information pack on project, its potential scope and environmental issues. All available conceptual and preliminary drawings and development plans must also be provided for HAZID. Input of major hazards identified to Hazards and Effects Register together with recommendations in priority order. An initial statement on hazard manageability and assurance needs.

2.2.7 HAZOP (Hazard and Operability Study)

HAZOP identifies the Hazards, Effects and Operability problems relating to the process design and intended method of plant operation which must be removed or managed in the operation. HAZOP can be divided into 4 stages.

Coarse HAZOP - Early study to identify basic flaws in design which would be costly to correct later.

Main HAZOP - Primary vehicle for identification of hazards, effects and operability problems. Held when the front end engineering design is almost complete so that systems can be covered in detail.

Final HAZOP - Coverage of those systems not sufficiently developed for consideration in the Main HAZOP, particularly vendor data, and a formal review of action responses to previous HAZOPs.

Procedural HAZOP - Identification of hazards and operability problems arising from procedures such as commissioning, maintenance and other non-continuous procedures. Health and environmental aspects must be included on the same basis as safety

A multi-disciplined team review using a structured step-by-step methodology with the application of parameter and guide word combinations to sections (nodes) of the system to identify hazards and operability problems normally with a facility but also with procedures.

Coarse HAZOP - Large nodes concentrating on major issues, requires a team of experienced senior engineers. The recommendations from a Coarse HAZOP may involve significant changes to the design.

Main HAZOP - Rigorous application of the technique to relatively small nodes, requires a team of experienced engineers with extensive project experience.

Final HAZOP - Rigorous application of the technique to relatively small nodes, requires similar team as for Main HAZOP with the addition of vendor representatives. At this stage recommendations should be concentrated on 'will it work' rather than 'it would improve the safety of design to have'.

Procedural HAZOP - Application of specialised guide words to operating procedures, requires a team similar to that for main HAZOP with greater emphasis on operational personnel.

The information needed to conduct HAZOP study are:

Coarse HAZOP - Basic layouts, process flow schemes (PFSs) and any operating/control philosophies that are available.

Main HAZOP - Process and Utility Process Engineering Flow Schemes, (PEFSs, UEFSs) Operating and Control Philosophies, Cause and Effect Diagrams, Process S Final HAZOP EFSs and Vendor drawings, data, previous HAZOP findings and responses and any design changes since last HAZOP.afeguarding Drawings, line lists, alarm and trip settings.

Procedural HAZOP - As for Main HAZOP and Operating Procedures.

HAZOP outputs or deliverables can be summarize:

Coarse HAZOP - Recommendations for adjustment to design options, QRA studies and other supporting investigations. A risk ranking may be given to assist in prioritising the actions. This list may be incorporated into the Hazards and Effects register for the project.

Main HAZOP - Recommendations to amend the design to remove or reduce hazards and operability problems. Categorisation of the recommendations into approximate risk groups to assist in prioritising the actions. This list should be used to update the Hazard register for the project.

Procedural HAZOP - Recommendations to amend the procedures to remove or reduce hazards and operating problems. This will allow Safety Critical Procedures/Operations to be identified.

2.2.8 Health Risk Assessment (HRA)

HRA is process for identification of health hazards in the workplace and subsequent evaluation of risk to health, taking account of existing control measures. Where appropriate, the need for further measures to control exposure is identified.

HRA consists of a number of steps:

Step 1 Define management's role and responsibilities and allocate resources

Step 2 Define structure for implementation (identify assessment units; assessment team; job types; tasks; hazardous agents)

Step 3 For each job type gather information on agents and their harmful effects; nature and degree of exposure; screening and performance criteria

Step 4 Evaluate the risk to health (assign severity rating and exposure rating)

Step 5 Decide on remedial action

Step 6 Record the health risk assessment

Step 7 Review the health risk assessment.

HRA requires Detailed information on hazards and effects (e.g. toxic properties of chemicals); exposures (e.g. exposure levels to toxic chemicals); performance of existing controls; information from health surveillance records, etc.

HRA, as a tool for use as part of HEMP, assists to identify, evaluate and control health risks related to the company's operations to a level 'as low as reasonably practicable'. The recommendations emerging from the HRA provide the input into the HSE MS to ensure ongoing control of health risks and continual improvement in health performance.

2.2.9 Job Hazard Analysis (JHA)

JHA is Identification of potential problems within a job task that could lead to hazardous situations. Elimination or reduction of the hazard by development of safe working procedures. The method is derived from Task Analysis. It is a structured step-by-step team analysis of the job. Initially the job is broken down into individual steps which are then analysed sequentially to identify potential injuries to personnel, damage to equipment and pollution of the environment. The controls and preventative measures are considered and if found to be inadequate remedial recommendations are made. Consideration is also given to the establishment of recovery measures if necessary.

JHA requires Job description, plans and drawings. Historical records of accidents and near misses. Team members with technical competence relevant to the job being analysed must also participate.

Step-by-step analysis of each job highlighting potential departures from normal practice, with associated hazards and recommendations for remedial action will be deliver from this technique. The analysis also identifies the accident prevention responsibilities for key personnel. The report can also be used as the basis for the development/ modification of operating/working procedures.

2.2.10 Physical Effects Modelling (PEM)

PEM will model the physical behaviour of the potential release of a hazardous fluid or substance and subsequent related events to determine a measure of the effect, in terms of loading, on people, the environment and assets for each potential outcome. The physical effects, such as dispersion, explosion over pressures and heat radiation are calculated as input to assess potential extent of loss of life or damage. Use of step-by-step modelling allows potential escalation scenarios to be assessed.

Detailed information on: physical properties, such as density and toxicity; environmental factors, such as wind velocity, humidity ambient temperature, and geometrical obstructions, confinement are input for PEM. Information on process flows and any mitigating measures, such as inventory ESD or blowdown systems will also assist this tool. Access to sophisticated consequence modelling computer programs, e.g. FRED, HG SYSTEMS and SCOPE will automate this technique.

This tool will deliver data on the potential consequential loadings of previously identified hazardous scenarios with respect to the potential effects to personnel, the environment and the facilities.

2.2.11 Process Hazard Review (PHR)

PHR is an assessment of the safety status of existing process plant. It is intended for use when a plant has been in operation for a considerable time and/or has undergone equipment modifications and operation changes. It is used to provide an HSE Assurance report for ongoing operations in advance of major modifications or for life extension evaluations. PHR is an 'expert review' led by an experienced leader, containing design engineers but heavily weighted towards plant operators and maintenance staff. The review primarily focuses on potential causes of 'loss of containment'.

The study progresses through the plant looking at each major equipment items, applying a leader's checklist (aide-mémoire) of causes of loss of containment. The current design and operation of the plant is assessed and a critical examination made of the revision history to identify any causes of release resulting from changes to the design and operation of the equipment item since commissioning.

The team also reviews any hazards arising from variations (due to the age of the plant) from current design or operating standards.

The technique assumes that most of the drawings are near to current status. The meetings are normally held on the plant with regular site visits to check any details not 'as built' on drawings. The latest version of the Process Engineering Flow Schemes (PEFS) is used as the major study document to ensure complete coverage of the scope of the study. Additional information required includes the cause and effect diagrams and the full revision history and incident reports for the plant together with changes in the operating envelope and operation/maintenance procedures.

The expertise of the team is of critical importance. Where data are incomplete the PHR technique is applicable but success relies heavily on the study team containing operating staff with considerable depth of experience and knowledge of the plant throughout its operating life.

Final report from PHR showing the identified hazards, their causes and the concern of the team together with recommendations for any remedial action including, if appropriate, more detailed HAZOP in discrete areas.

2.2.12 SAFOP (Electrical Safety and Operability Study)

SAFOP is the identification of potential hazards to personnel in the vicinity of electrical systems. Critical assessment of electrical network and plant design and analysis of operator actions to determine areas of potential operator error. This process also includes making recommendations to eliminate or reduce risks.

A multi-disciplined team and a structured step by step methodology are used.

SAFAN - Hazards present in construction, commissioning and operation of electrical systems are examined in relation to the safety of personnel in the vicinity.

SYSOP - Examination is made of the control systems, the main items of plant and their auxiliaries in relation to any limitations and their effects on the overall system operability.

OPTAN - Considers probable tasks to be under taken during normal and upset conditions. The usability of equipment and clarity of instructions are reviewed with the aim of reducing the potential for human error as low as is reasonably practicable.

Detailed electrical system design and layout drawings, control circuit diagrams, system designs and functional specifications, and electrical system operating and emergency procedures are needed to conduct SAFOP. A report will be produce from SAFOP. Report detailing the findings of the audit and where necessary suggest some recommendations categorised as 'Strongly Recommended', 'Advice' or call for further information 'Information Required'.

2.2.13 Structural Consequence Analysis (SCA)

SCA is an assessment of the response of a structure under fire conditions. Determination of the extent of any failure under fire loading and, if necessary, proposal of remedial measures. Coarse analysis is based on determining the time to failure of the structure from linear elastic techniques. This analysis determines those structures which are critical and which should be the subject of more detailed analysis. Detailed analysis is based on non-linear analysis methods. These allow the true collapse load of the structure to be estimated by modelling elastic-plastic behaviour of the structure at elevated temperatures. The USFOS analysis program may be used for these studies.

SCA requires details of potential fires from FEA , data on the type and layout of existing fire protection facilities. Detailed structural drawings.

Report on the ability of the structure to withstand the fire scenarios identified will be deliver. This will reveal if there exists the potential exists for fire to lead to progressive collapse of the structure or loss of the TR within the required endurance period. If necessary recommendations for remedial actions and distribution of protective equipment should be made.

2.2.14 Temporary Refuge/Escape, Evacuation and Rescue Analysis (TR/EERA)

TR/EERA is the analysis of escape to TR, the provisions within the TR system, and Evacuation, Escape and Rescue with respect to the major scenarios previously identified for comparison against respective acceptance standards highlighting critical elements and revealing any shortfalls.

The EERA/TRA comprises three related elements:

a goal analysis which considers how the goals for the EER process will be satisfied in likely EER situations as a basis for determining the adequacy of the proposed arrangements

an escape and evacuation time analysis which considers the time needed to complete all phases of the EER process under conditions which may be present when there is a need for EER

a TR impairment analysis to determine the frequency that the TR and related evacuation facilities will be impaired.

TR/EERA requires detailed information on the TR/EERA provisions and details of the major hazard scenarios identified. Details of installation layout including muster stations, refuges, evacuation points and escape to sea facilities. Input data from Fire and Explosion Analysis (FEA), Smoke Ingress Analysis (SIA) and Emergency Systems Survivability Analysis (ESSA).

This technique will produce a formal record of the EER facilities and arrangements with details of the direct and escalated impact of the identified hazard scenarios coupled with considerations on the likelihood of their occurrence.

2.3 Conclusion remarks

HSE MS is a structured set of controls for managing HSE; to ensure and to demonstrate the HSE objectives set in the policy are met. HSE MS is widely applied in current business as requirement. The main objective of implementing HSE MS is to ensure all hazards and risks are at ALARP. HSE tools represent HSE elements that are needed to be in place to achieve this. Literature study reveals there is a weakness in integration of HSE MS and HSE elements and also data management of current practice. This study aims to tackle these issues. Therefore, this upholds the originality of this study to develop a HSE MS tool.

CHAPTER 3.0
METHODOLOGY

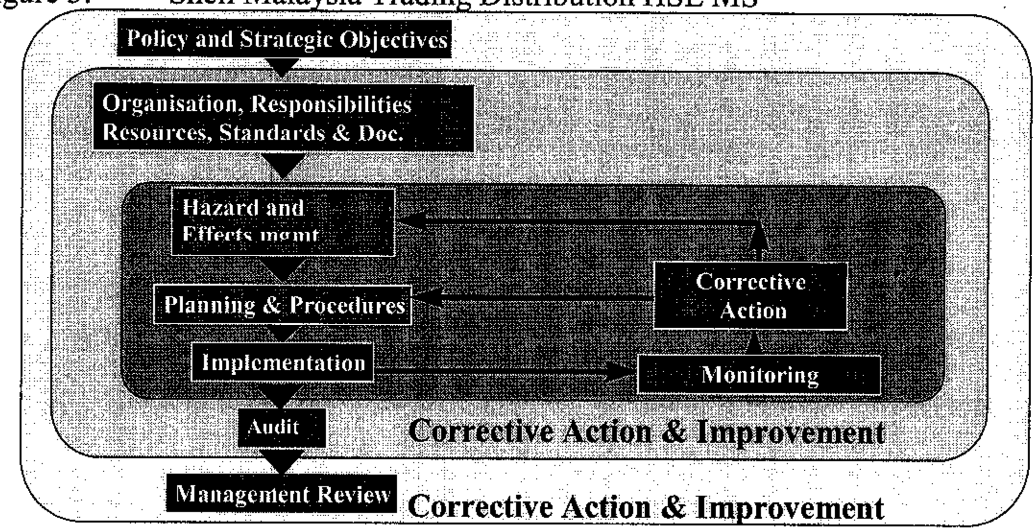
3.1 Procedure Identification

This research project can be divided into 3 major phase. The first phase is study of current HSE MS. The second stage is integration of HSE elements into the developed HSE MS. The final stage of this project is to convert this integrated system as a software application for usage. Shell Malaysia Trading Distribution Bagan Luar depot will be the focal point of this study.

3.1.1 Study of HSE MS Model

The first phase in completing this research is to familiarize with HSE MS elements. There is also the need to review current practice HSE MS. Shell Malaysia Trading Distribution HSE MS was studied as the basis for this project. This is due to the fact that Shell Malaysia Trading Distribution depot at Bagan Luar is the case study for this project. The current HSE MS applied in Bagan Luar depot

Figure 3: Shell Malaysia Trading Distribution HSE MS



This phase also include study of the depot itself. The activities and present identified hazards at depot were obtained through depot HSE Case and Hazard Register. The depot is segregated into 4 zones for the purpose of this project. The zones are:

Jetty Operations (JO) – this zone covers the jetty within the depot where tankers and ferries berth. Tankers supply the refined oil while ferries refill their tanks.

Tank Farm (TF) – this zone covers the bounded tank area at this depot. This are represents the peak hazard level at the depot. The tanks in this zone are storage tanks, doping tanks and skid tanks. The refine oil from jetty is supplied through pipeline to doping tank. After addition of additives the fuel will be stored in storage tank.

Filling Gantry (FG) – this zone is interconnected to storage tank through a pipeline. Tankers are filled with fuel at this zone.

Storage Facility (SF) – this zone is located between the jetty and tank farm. Additives and waste are stored here.

3.1.2 Integration of HSE elements in HSE MS – Design of HSE MS tool.

The integration of HSE elements into HSE MS is actually the designing phase of the HSE MS tool itself. The key goal in integrating HSE elements is to ensure hazards and risk at ALARP. There are 4 major elements integrated in HSE MS in achieving this goal.

The first element is to recognize and acknowledge the presence of hazard in depot operations and activities. The HSE element similar to this is hazard mapping. A hazard map that illustrates the hazard at classified zone of depot is integrated in the HSE MS tool. This map also illustrates the activities conducted at the specified zone. This map was prepared through study of depot HSE Case.

The second element is performance monitoring. This is a control in HSE MS. Performance monitoring is an essential HSE element in generating good HSE performance. EQA 1974 also requires industrial practitioners to monitor the environment performance. The developed HSE MS tool encompasses performance monitoring of HSE Key Performance Indicator (KPI), hazardous waste and accident reports. The parameters and database for HSE KPI, hazardous waste and accident reports was generated for the HSE MS tool after consultation and reference with supervisor and external supervisor.

The third HSE element integrated in HSE MS is the Hazard Effects Management Process (HEMP). HEMP is the most important HSE elements in achieving ALARP. The principles and basis of HEMP are summarized in the following steps. The findings will be recorded in the Hazard Register in the develop HSE MS tool:

1. 'identify'
2. 'assess'
3. 'control' and
4. 'recover'

Step 1 is to systematically identify the hazards, the threats and potential hazardous events and effects which may affect, or arise from, a company's operation throughout the total life cycle of the operation.

Step 2 is to systematically evaluate (assess) the risks from the identified hazards against accepted screening criteria, taking into account the likelihood of occurrence and the severity of any consequences to employees, assets, the environment and the public. This includes the risks associated with deviation from limits set for environmental and occupational health hazards.

Step 3 and 4 will evaluate and implement appropriate measures to reduce or eliminate risks. Risk reduction measures include those to prevent or control incidence (i.e. reducing the probability of occurrence) and to mitigate effects (i.e. reducing the consequences). Mitigation measures include steps to prevent escalation of developing abnormal situations and to lessen adverse effects on Health, Safety and the Environment. Risk reduction measures also include recovery preparedness measures which address emergency procedures as well as restoration and compensation procedures to recover.

HEMP was developed to provide a structured approach to the analysis of safety hazards throughout the life cycle of this depot. The arrangements identified as necessary to manage assessed threats and potential consequences and effects are then incorporated for existing operations as Hazard Register. HEMP in the HSE MS tool covers both qualitative risk assessment and quantitative risk assessment.

Qualitative risk assessment employs experience and judgment in conducting HEMP. Results from this assessment are incorporated in Hazard Register in this tool. HSE tools integrated in the developed HSE MS tool to assist qualitative risk assessment are Risk Assessment Matrix, Bowtie diagram and HAZOP.

Quantitative risk assessment provides a structured approach to assessing the potential for incidents and expressing this potential numerically. Statistical values are derived for potential loss of life and damage to resources and environment. These values should not be interpreted as unavoidable and acceptable losses resulting from the operations considered, but as a yardstick to measure safety, to raise awareness for the potential of accidents and thereby developing measures to prevent them. HSE tool adapted in the developed HSE MS tool to facilitate quantitative risk assessment is Fault Tree Analysis (FTA). Quantitative risk assessment for this study only focuses on tank farm. This is because tank farm is the highest hazard level zone at the depot.

The final element integrated in the developed tool is Emergency Response Preparedness (ERP). ERP was developed for the depot through study of various practiced ERP. The presence of ERP in developed HSE MS tool signals the depot is prepared and proves identified hazards and risks are at ALARP.

3.1.3 Development of HSE MS tool

The development of HSE MS tool requires literacy in IT. Therefore, trade of identified programs and software needs to be acquired to complete this project. The project is now in its final phase which is the execution phase. The HSE MS tool which was design in previous phase will be converted as a software application during this phase. The tools identified have been finalized after considerations of several alternatives based on current available resources. The tools will be integrated in developing the HSE MS tool. The integration of these tools is presented in Figure 3.2

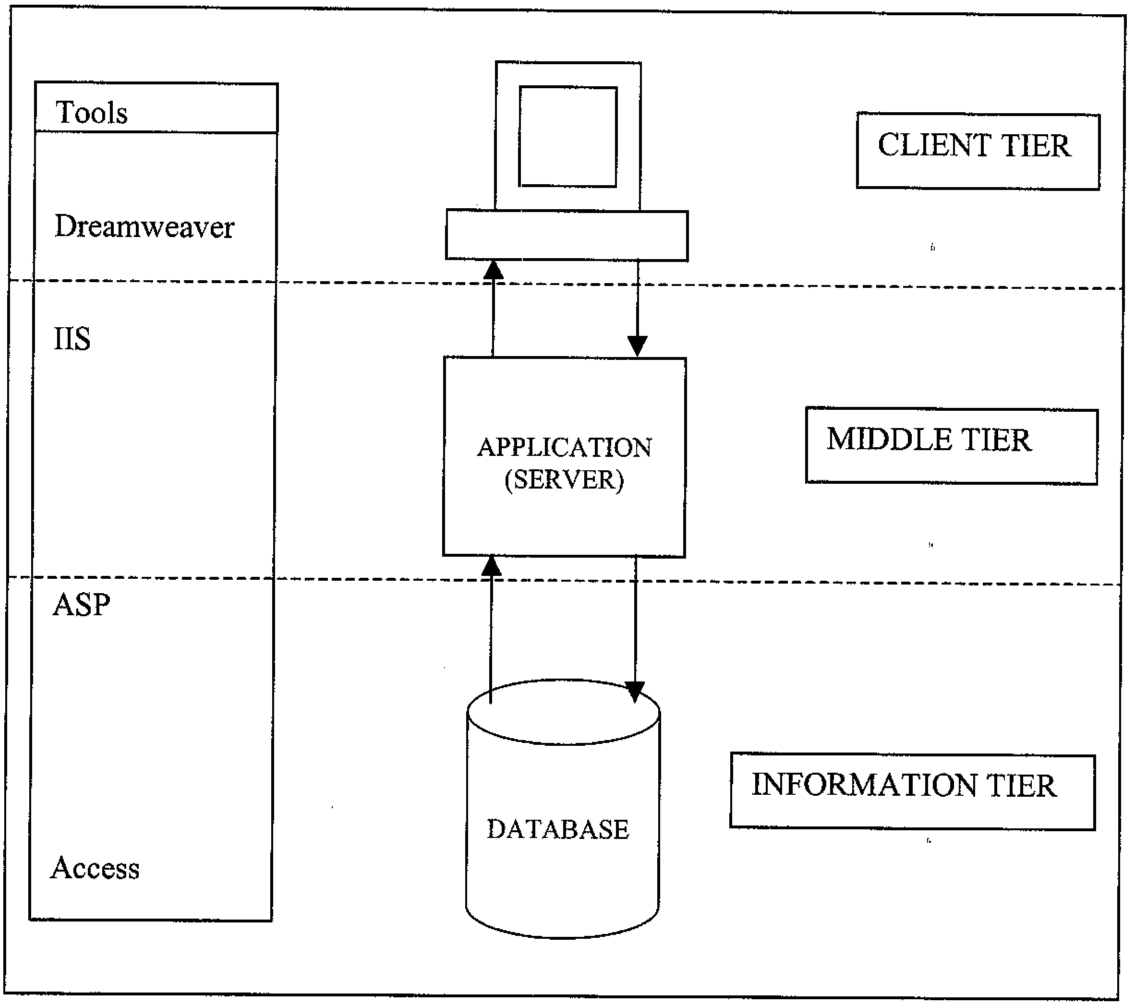


Figure 4: System architecture of HSE MS tool

Figure 2 describes the system architecture for the HSE MS tool that is developed in this study. The developed system is a three tier application model.

Client tier

Middle tier

Information tier

The client tier is the interface that will be display for users of this application. User will input data and retrieve data using this interface. Dreamweaver with simple multimedia function from Macromedia Flash will be manipulated for the client tier. The interface will be interactive. User can input data for performance monitoring into HSE KPI database, hazardous waste, accident reports and investigations into database of past accidents, emergency response exercise into the emergency response exercise database and also audit items into the audit database. The terminal operations and activities will be represented in map form and user can retrieve the data and hazard register data by simply clicking on areas on the map.

The information tier will be developed using Microsoft Access. There will be 8 databases for this tool. User will trigger application on interface to retrieve the databases. The middle tier controls interaction between application clients and application data. It acts as an intermediary between data in information tier and client tier. IIS is the front end of the middle tier and it will act as the server or host. Active Server Page (ASP) is the scripting for IIS. The middle tier will control data traffic of input on interface to database and retrieval of data from database to interface

3.1.4 Computer networks

Transparency is another added feature in this HSE MS tool. It is well known that the Achilles' heel of current HSE MS is that it is in manual form. It will not only result in loss of data of HSE MS and inefficiency but also limits the coverage area. This tool will enable personnel to access and explore HSE MS tool through network. This is because the HSE MS to is a simple application software that can launch from desktop computers. Local Area Network facility at depot creates a launch pad for transparency and widens coverage area of HSE MS. Therefore, more people will understand and apply HSE MS tool in their job and subsequently this will create an efficient HSE MS. Efficient here refers to ability to achieve ALARP and also cultivate good HSE culture among personnel.

They are two major categories which communication networks are traditionally classified which is:

a. wide area networks (WAN)
b. local area networks (LAN)

Wide area network covers a large geographical area, require the crossing of public right-of-ways, and rely at least in part on circuit provided by a common carrier. WAN consists of a number of interconnected switching nodes. A transmission from any one devices is routed through these internal nodes to the specified destination device. These nodes are not concerned with the content of the data. WAN is implemented using technologies as listed below:

a. circuit switching
b. packet switching
c. frame relay
d. ATM
e. ISDN and Broadband ISDN

LAN is a communication network that interconnects a variety of devices and provides a means for information exchange among those devices. LAN makes use of a broadcast network approach rather than a switching approach. With a broadcast communication network, they are no intermediate switching nodes. At each station, there is a transmitter/receiver that communicates over a medium shared by other stations. A transmission from any one station is broadcast to and received by all other station. Data are usually transmitted in packets. Because the medium is shared, only one station at a time can transmit a packet.

They are several key distinctions between LANs and WANs. The scope of LAN is usually small, typically a single building or a cluster of buildings. This is what always be differentiate between LAN and WAN. The internal data rates of LAN are also much greater than those of WANs. Figure 1 below shows how LANs and WANs work.

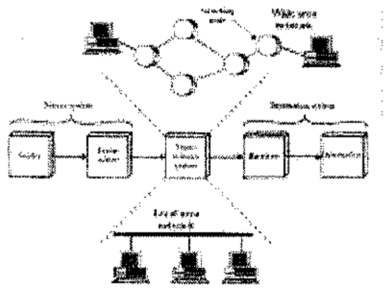


Figure 5: Application of LAN and WAN

3.2 Tools Required

3.2.1 Dreamweaver

Dreamweaver will be utilize to create interface for the client tier. Users will input and view retrieved information from HSE MS tool through this interface. The interface will only be functional for display. Dreamweaver can be integrated with Macromedia Flash to enhance multimedia characteristic of the interface. Thus, a more interactive and interesting interface will be develop for the HSE MS tool. The other considered tool for client tier was Microsoft Visual Basic but Dreamweaver was preferred as its application is drag and drop basis and requires minimal scripting compared to Microsoft Visual Basic. Furthermore, Dreamweaver produces more interesting and refreshing interface compared to Microsoft Visual Basic.

3.2.2 Microsoft Internet Information Services (IIS)

IIS is an enterprise-level web server that is included with Microsoft 2000. IIS is applicable for both LAN and WAN usage. It allows computers to serve documents. IIS will allow computer to act as host or server to connect client tier and information tier. IIS will be the front end of the middle tier. IIS will control data traffic between client tier and information tier. IIS was chosen on the basis that the identified facility uses Microsoft 2000 as its operating system.

3.2.3 Active Server Pages (ASP)

ASP will be utilized as back-end of the middle tier. ASP is a server technology that dynamically builds documents in response to client requests. ASP will be in the form of source code or scripting. ASP is processed by an ActiveX component called a scripting engine. An ASP file has the file extension .asp and the common languages like JavaScript and VBScript are used as for ASP scripting. ASP was chosen because it is the back-end and scripting program for IIS.

3.2.4 Microsoft Access

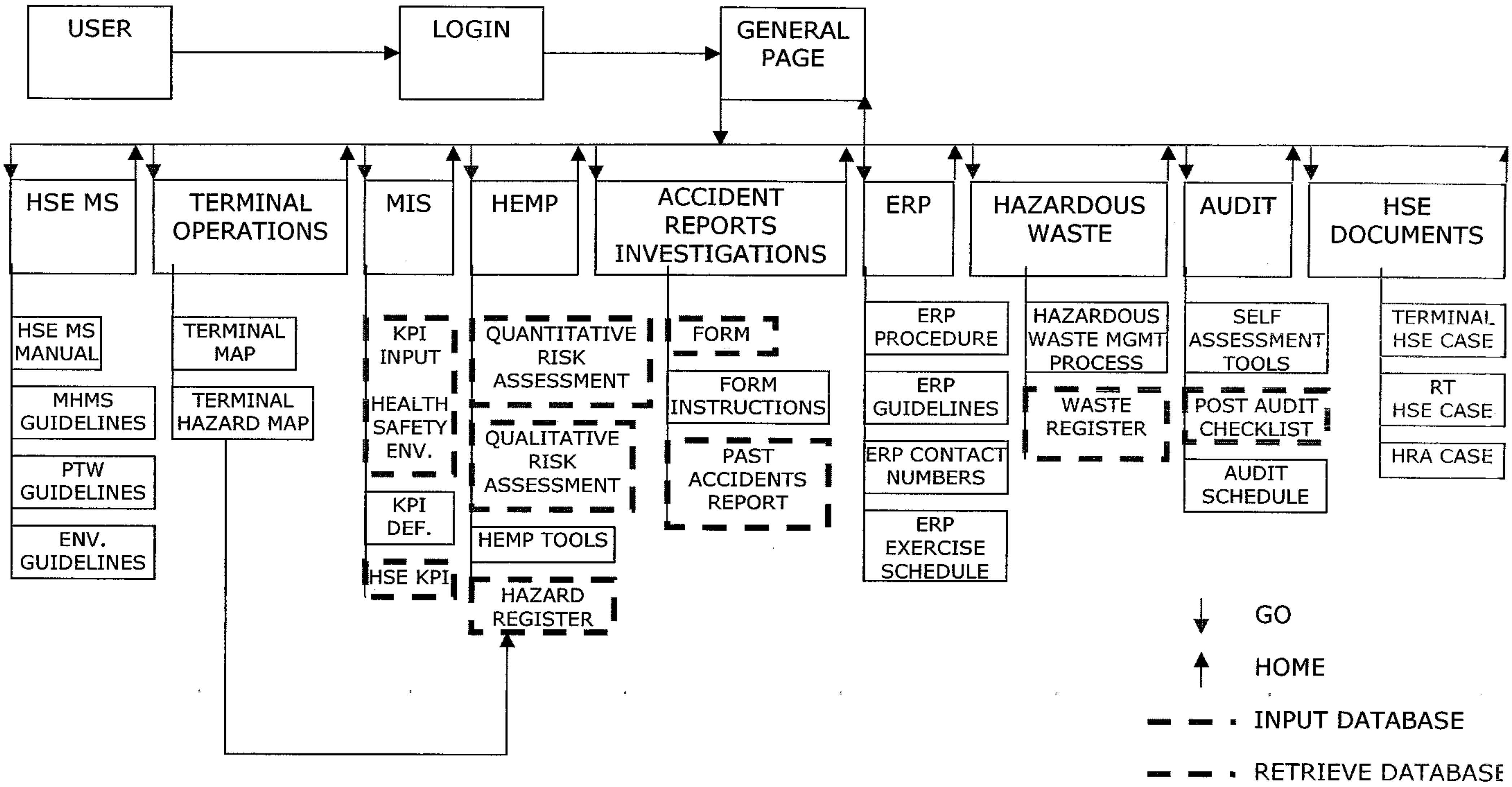
Microsoft Access is utilized as database for HSE MS tool. Microsoft Access is the information tier. The database will store all input data and also stored data for the retrieval by user. Microsoft Access was preferred because it is not complex and user friendly compared to Oracle and Visual Basic. Microsoft Access provides an interface for user to build database but Oracle requires user to do scripting. Microsoft Access is the obvious alternative as time is constraint in completing this study and learning scripting requires considerable time resource.

CHAPTER 4.0

RESULT AND DISCUSSION

Figure 6 represents the system flow for HSE MS tool. The usage of this tool should eliminate indicated weaknesses of currently practice HSE MS. The glaring weakness would be the fact HSE MS is manual oriented and therefore there are tendency of misplacement or loss of data. This impairment can lead to disastrous effects. It is well documented that the Piper Alpha and Longford incidents are retribution due to this weakness. The embedment of HSE MS tool in operations of depot should the least minimize the probability reoccurrence of such tragedy. This tool through the integrated HSE elements helps to maintain hazards and risks at ALARP.

HSE MS tool can be divided into 3 levels as depicted in figure 4.1. Level 1 comprises login and general page. Level 2 compromises HSE MS, terminal operations, performance monitoring (MIS), Hazard Effects Management Process (HEMP), accident reports and investigations, Emergency Response Preparedness (ERP), hazardous waste, audit and documents page. Level 3 is dependent subsystem for Level 2 pages. This section will discuss the elements of this tool according to the 3 levels. Discussion on Level 3 will be inclusive in Level 2.


USER
LOGIN
GENERAL PAGE
HSE MS
TERMINAL OPERATIONS
MIS
HEMP
ACCIDENT REPORTS INVESTIGATIONS
ERP
HAZARDOUS WASTE
AUDIT
HSE DOCUMENTS
HSE MS MANUAL
MHMS GUIDELINES
PTW GUIDELINES
ENV. GUIDELINES
TERMINAL MAP
TERMINAL HAZARD MAP
KPI INPUT
HEALTH SAFETY ENV.
KPI DEF.
HSE KPI
QUANTITATIVE RISK ASSESSMENT
QUALITATIVE RISK ASSESSMENT
HEMP TOOLS
HAZARD REGISTER
FORM
FORM INSTRUCTIONS
PAST ACCIDENTS REPORT
ERP PROCEDURE
ERP GUIDELINES
ERP CONTACT NUMBERS
ERP EXERCISE SCHEDULE
HAZARDOUS WASTE MGMT PROCESS
WASTE REGISTER
SELF ASSESSMENT TOOLS
POST AUDIT CHECKLIST
AUDIT SCHEDULE
TERMINAL HSE CASE
RT HSE CASE
HRA CASE
GO
HOME
INPUT DATABASE
RETRIEVE DATABASE

4.1 HSE MS Tool Interface

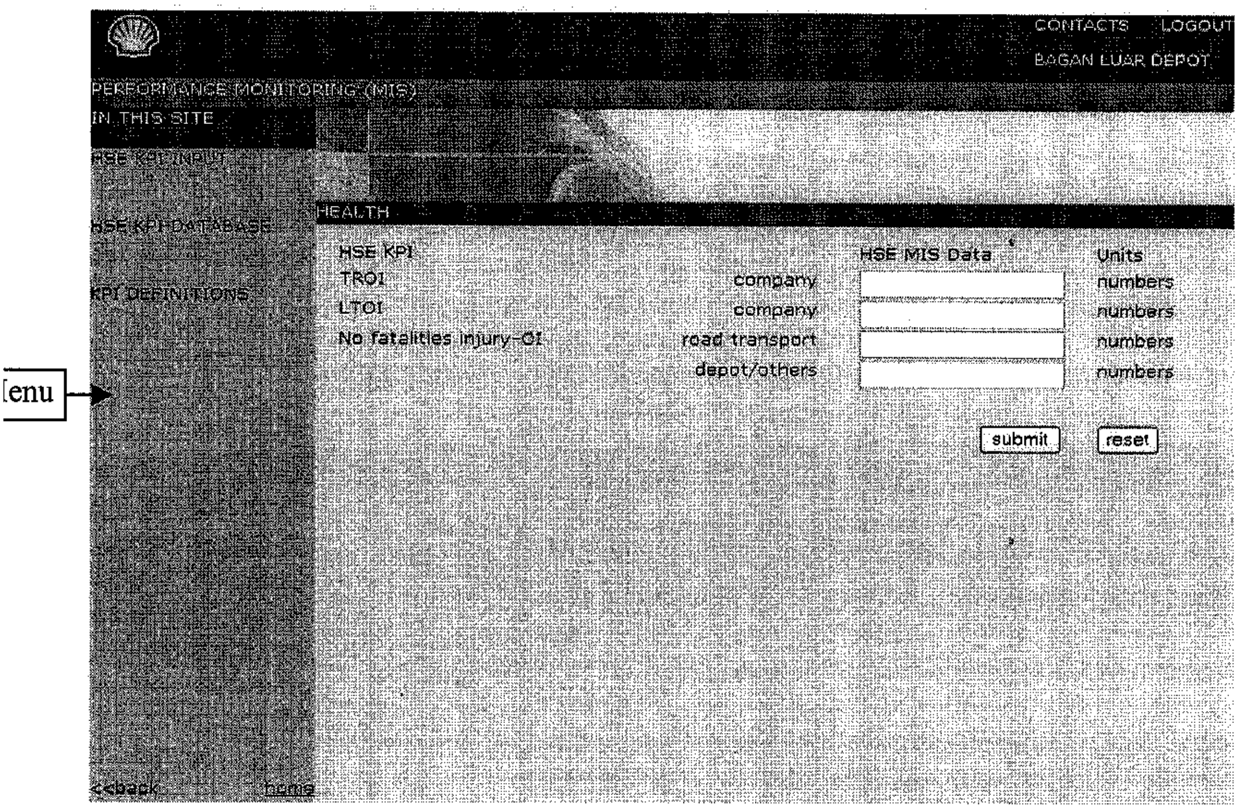


Figure 7: HSE MS tool interface sample

HSE MS tool interface is attached in figure 7. A standard interface format was developed for this tool. This step was taken to make tool user friendly and easily navigated. The interface below is for Performance Monitoring (MIS) page. Table 1 describes the function button on the interface.

Command button	Description
Menu	List the pages that can be explore by user Transport user to specific page by clicking on menu
Back	Transport user to previous viewed page
Home	Transport user to general page which is the navigation page

Contacts	List the contacts number for ERP
Logout	User can exit tool through this button
Submit	Transport input data to database
Reset	Clear input data by user
Input	User input data into tool

Table 1: Interface command buttons description

4.2 Level 1

Level 1 compromises login and general page. Login page acts as security barrier for tool. Client or user must key in username and password. User will be transported to general page upon completion of this procedure. There are 3 types of clients:

Guest

User

Administrator

Clients type can be differentiate according to access to tool. Guest only has the rights to view tool. Guest covers contractors and visitors at depot. They can use this tool to refer to manuals, observe performance monitoring and also hazards present at the depot. Therefore this tool acts as an induction kit for first time visitors at depot. This tool will help them to understand the hazards at the depot and make the aware and prepare before entering depot environment. This will also cultivate good HSE culture among users.

User level client have the privileges to input data into the tool databases. User level usually encompasses supervisors and executives at depot. They are the personnel held accountable in monitoring KPI, submitting data for HEMP, submitting accident reports, parameters for hazardous waste management and also audit findings for action. User level client are vital in ensuring the tool is living and fully utilized.

The highest level client is administrator. Administrator access is assigned to depot manager and also HSE Advisor. Administrator has privileges to input data into tools and also delete and modify tool features. The main role of admistrator is vet data in tool. This will ensure tool is living and accurate. Thus, optimizing efficiency of this tool.

User will be transported to general page once tool recognize their level of authority in accessing the tool. General page is the navigation page for this tool. Menu on general page list all level 2 elements in this tool. It is worth noting that the level 2 elements are the most important feature for this tool. This is because they are the HSE elements integrated in this tool and they are the controls of HSE MS. The general page will transport user to the desired page on level 2.

4.3 Level 2

4.3.1 HSE MS

Standards, procedure and works instructions are among controls embedded in HSE MS to achieve HSE objectives. This tool covers these controls of HSE MS. This contains the HSE MS manual for A+ Distribution which covers Bagan Luar depot. Personnel inclusive of contractors and visitors to depot can view HSE MS manual to better understand concept of HSE MS. This will raise awareness and knowledge of hazards at depot and achieve goals of maintaining hazards at ALARP. Raise of HSE literacy will also cultivate HSE culture which will improve HSE performance of depot. This page also offers standards for Minimum Health Management Standards (MHMS), Global Minimum Environmental Requirements Standard. These are the standards set by Shell which are utilized as controls in this tool. There is also a manual on Permit to Work (PTW) system which ensures safe work practice in operations of Shell terminals.

4.3.2 Terminal Operations

Hazard mapping is among HSE elements identified to be integrated in this tool. Terminal operations page helps user to recognize and acknowledge presence and location of hazard at depot. The terminal hazard map segregate the depot into zonal section as mentioned in Methodology section. Terminal hazard map list the present hazards on the depot map on zonal basis. This map is interconnected to hazard register. The hazards register in under HEMP page. This feature of the tool will enhance personnel awareness of where hazards are located. Precautionary action can be taken by personnel upon venturing hazardous locations in depot. This feature can also assist new personnel to know the depot and its hazard. These advantages can help the depot maintain good HSE performance and support in ensuring HSE MS fulfill its purpose.

4.3.3 Performance monitoring (MIS)

Performance monitoring is an essential HSE element in generating good HSE performance. EQA 1974 also requires industrial practitioners to monitor the environment performance. Relevant Key Performance Indicators (KPI) has been identified for monitoring of depot performance. The KPI are segregated into health, safety and environment. The KPI must be updated on monthly basis by accountable personnel. This staff shall be granted user level access to the tool. Input data for parameters will be stored in database and can be retrieved for viewing. Environment parameters will be automatically submitted to DOE on monthly basis. These parameters are deemed compulsory for monitoring under EQA 1974. HSSE Advisor for Shell Malaysia Trading Distribution also requires depot to submit all HSE parameters on monthly basis. This is a scorecard item which will no appraise HSE performance but also affects business performance of depot. This feature of the tool will manage data systematically for present and future utilization. Performance monitoring feature will not only help achieve HSE objectives but it will also ease workload in submission of parameters. Appendix 2 depicts the KPI monitored using this HSE MS tool.

4.3.4 Hazard Effects Management Process (HEMP)

Hazard Effects Management Process can be defined as the most integral feature in this tool. As defined in Methodology section, HEMP provides a structured approach to the analysis of safety hazards throughout the life cycle of this depot. The arrangements identified as necessary to manage assessed threats and potential consequences and effects are then incorporated for existing operations as Hazard Register. HEMP in the HSE MS tool covers both qualitative risk assessment and quantitative risk assessment.

Once hazards and hazardous events have been identified, their causes, consequences and probability can be estimated and the risk determined. Risk assessment may be on a qualitative or quantitative basis. Both involve the same steps. Qualitative methods may be adequate for risk assessments of simple facilities or operations where the exposure of the workforce, public, environment or the asset is low. Bagan Luar depot can be classified as a simple facility. Therefore, qualitative risk assessment will be introduce extensively in this developed tool. However, the application of quantitative methods is considered to be desirable when:

several risk reduction options have been identified whose relative effectiveness is not obvious

the exposure to the workforce, public, environment or the strategic value of the asset is high, and reduction measures are to be evaluated

demonstration of relative risk levels and their causes to the workforce is needed to make them more conscious of the risks

It is identified from qualitative risk assessment that hazard of fire at tank farm area is high and usage of quantitative risk assessment for this hazard is needed. This was justified by above mentioned statements.

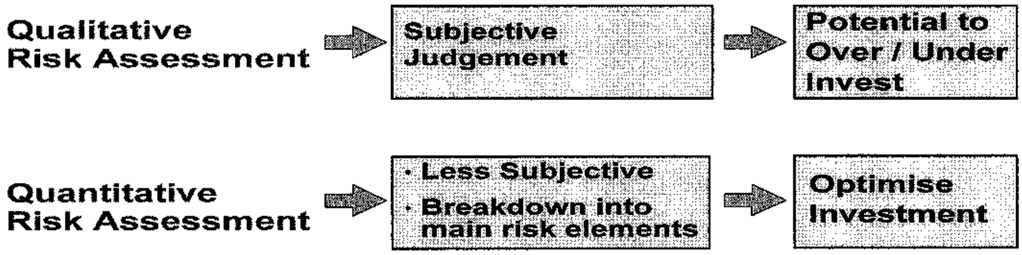


Figure 8: Quantitative versus qualitative assessment

Risk is often defined as a function of the chance that a specified undesired event will occur and the severity of the consequences of the event. When risk is assessed qualitatively a Risk Assessment Matrix (RAM) may be used. When assessed quantitatively, risk is derived from the product of chance and potential consequence. For quantitative RA purposes, chance is usually expressed as the frequency of occurrence. If no attempt is made to estimate the frequency, we may be driven by the consequence into investing heavily on risk reduction measures which are ineffective.

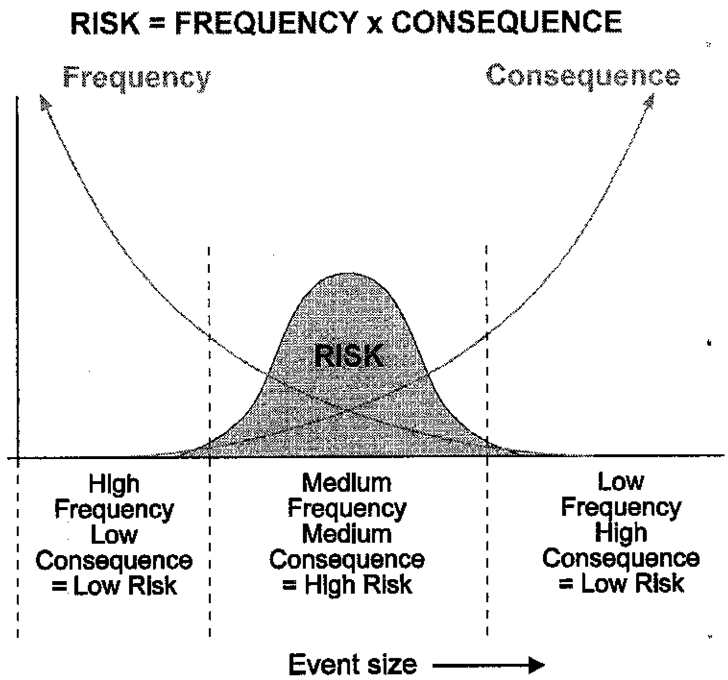


Figure 9: The importance of quantification

Many are concerned about the accuracy of the quantification and use this as a reason why the technique should not be applied. However, whether we realize it or not, we are always making implicit comparative quantification whenever we make a decision. What we gain with QRA is a structured assessment of the risk instead of an intuitive type of quantification. The numbers used in a QRA may be very approximate, but at least we have broken down the problem into its basic elements and made an objective judgement for each of these elements rather than an overall judgement on a largely subjective basis.

QRA is a powerful decision-making tool which can assist in the selection of acceptable solutions to safety problems. This technique can be defined as the formal and systematic approach to identifying hazards, potentially hazardous events, and estimating likelihood and consequences to people, environment and assets, of incidents developing from these events. The total process of risk analysis, interpretation of results and recommendations of corrective actions is usually called 'Risk Assessment'. The application of QRA has contributed not only to increased safety but also to improved cost effectiveness in many areas.

A HSE tool used in this HSE MS tool for quantitative risk assessment is Fault Tree Analysis (FTA). This feature in the develop tool is only applicable for quantification risk of fire at tank farm. Fault Tree analysis is a common probabilistic technique applied in reliability analysis and, to a lesser extent, risk assessment. It allows the user to concentrate on a particular system failure, which is usually giving rise to the 'top event' or 'branch event' of an Event Tree. The Fault Tree approach traces back the possible causes of an identified 'top event' or 'branch event'. This analysis is characterised by the question: 'How can it occur?', The forward analysis is the Event Tree analysis; it starts with an initiating event ('top event') and projects possible consequences from that event. This analysis concentrates on the question: 'What happens if it occurs?' In general the construction of Fault Trees and Event Trees can only be achieved by relying on the experience of those persons who are familiar with the real system under consideration.

Fault Trees cannot take account of sequential failures or time dependency. This limits their usefulness in risk analysis where the development of scenarios with time is important. A Fault Tree consists of two types of building blocks: GATE symbols and EVENT symbols. Events are represented by rectangles. GATE symbols connect events according to their causal relations. GATES may have two or more input events but only one output event. In this tool only two types of GATES, the OR GATE and the AND GATE will be used. Other gates, such as the NOT gate and the INVERSE gate are not considered.

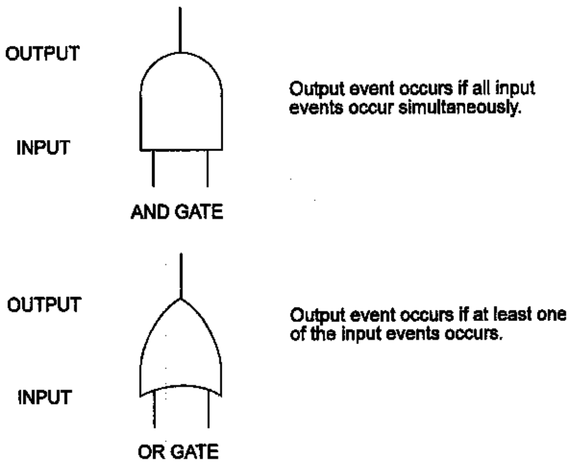


Figure 10: AND GATE and OR GATE

All possible combinations of gates and events are allowed, provided the following two conditions are satisfied:

a. The Fault Tree must have a typical tree structure, ie all events and gates should converge into a single event : the top event.

b. Events are connected by gate symbols, ie an event is never directly connected to another event.

Often the construction of Fault Trees is a useful exercise in itself, for it provides an insight into the possible failure modes of sometimes rather complex systems. However, the success of Fault Trees is mainly due to the quantitative aspects. The probability calculus associated with AND and OR gates is a direct result of the standard ways in which probabilities can be combined. It can be used to calculate the probability of an event occurring within a certain time interval (alternatively the frequency of such an event) or the probability of failure on demand (unavailability). The definition of the top event is important both for deriving the appropriate logic and the calculus of probabilities.

FTA was performed for top event of major fire occurrence at tank farm. There 2 FTA diagrams that are featured in the developed HSE MS tool under quantitative risk assessment. The first FTA deals with top event of fire break out at tank farm and the second FTA is more detailed with top event of major fire occurrence at tank farm. Both FTA are represented in figure 11 and figure 12.

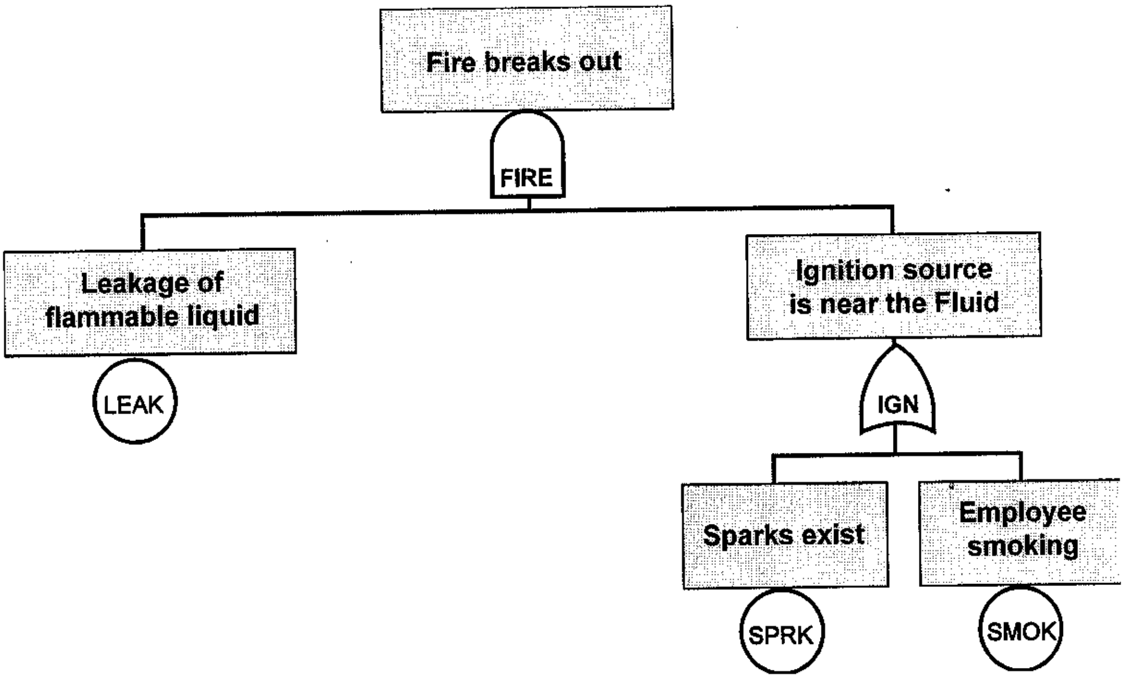


Figure 11: FTA for major fire hazard

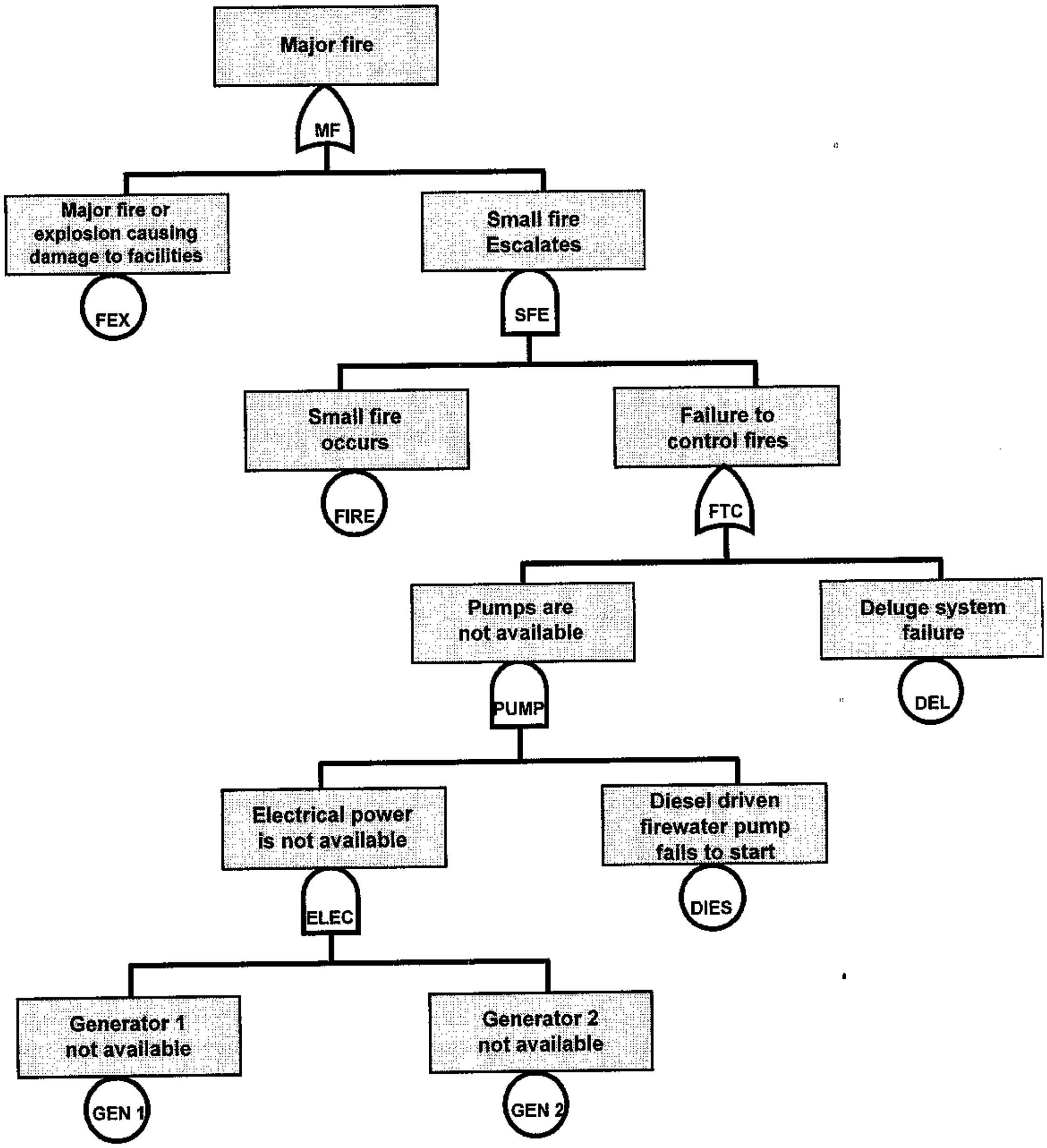


Figure 12: FTA major fire occurrence at tank farm

Note: The text in the circles and gate symbols is used to provide a convenient label in probability calculation formulae.

HSE MS tool will automatically generate probability of top event once user provides the system with probability of risk for basic events. Basic events can be a frequencies or probabilities. User should provide the accurate data base on statistical data of operations at depot according to theory of probability and statistic.

QRA is features extensively in this tool. This assessment will conducted base on the experience and judgement. Qualified personnel in groups should have user access to this tool to complete qualitative risk assessment. This assessment is base on the HEMP process with aim to maintain all identified hazards at ALARP. Therefore this tool follows the 4 step procedure of:

1. 'identify'

2. 'assess'

3. 'control' and

4. 'recover'

Identifying hazards for this depot will be performed using Hazard and Operability Study (HAZOP). HAZOP is a systematic process to identify and manage the hazards associated with change in the business; physical, procedural and process, management and organizational and temporary changes. This is useful HSE tool that have been in incorporated in this HSE MS tool. HAZOP study was developed by ICI in the UK in the 1960's and is now widely used throughout the chemical and petroleum industries. It is based upon the supposition that most problems are missed because the system is complex rather than because of a lack of knowledge on the part of the design team.

The purpose of a HAZOP study is to identify potential hazards under all foreseeable conditions. It should be incorporated as a step in the overall procedure for Change Management, both in terms of safety and also the operability of the processes and plant. The objective of effective change management, including temporary changes, being to facilitate the efficient implementation of organisational changes and smooth, safe and prompt commissioning of new plant, without extensive last minute modifications, followed by trouble of continuing operations. A HAZOP study can also be used in part as a training aid for plant personnel and in the preparation of Operating Manuals
The HAZOP study can be used on a new/existing procedures, organisation changes, operational activity, or as a way of rigorously and systematically checking a design for safety, operability and conformity with codes of practice etc. HAZOP study report can

be used to demonstrate to interested external (Government/Community/etc) parties that all possible action has been taken to identify and eliminate hazards.

The procedure adopted in a HAZOP study is based on the generation of questions that ensure comprehensive and systematic coverage of all the relevant areas in the design of a change. These questions are asked in an ordered and creative manner by design and operations personnel with the appropriate experience and expert knowledge of the particular process design. The aim of the questions is to identify any design faults, process deviations or system shortfalls that might exist which would lead to safety or operability problems. The plant is considered section-by-section, line-by-line, and item-by-item, but never in complete isolation. The questions on the process are based around guidewords, which investigate deviations from the intention of the change. The guidewords ensure that the questions will explore every conceivable way in which the operations could deviate from the design intention.

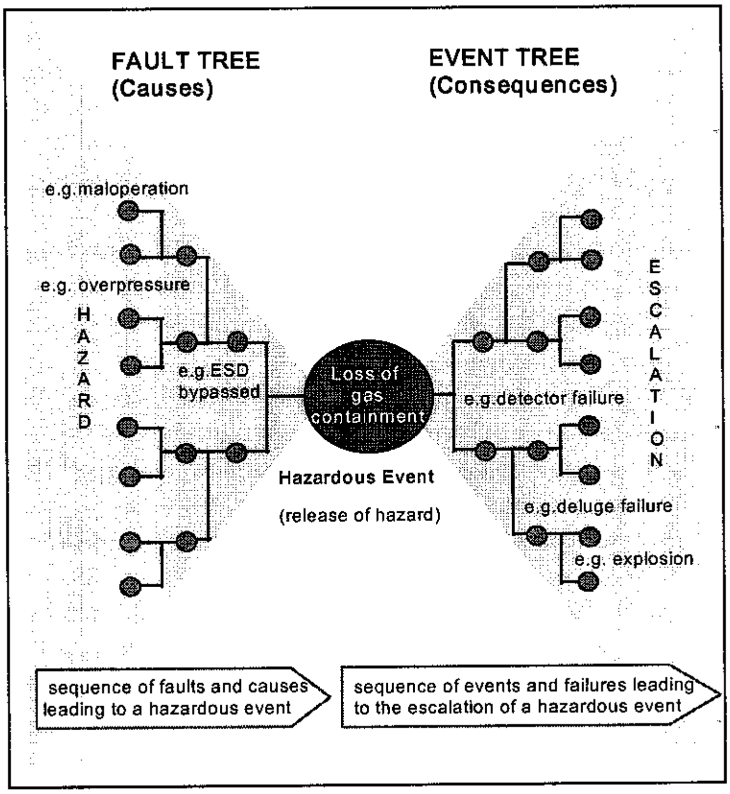
A multi-disciplined team review using a structured step-by-step methodology with the application of parameter and guide word combinations to sections (nodes) of the system to identify hazards and operability problems normally with a facility but also with procedures. The team should consist of experienced engineers with extensive project experience and depot operations experience, vendor representatives, contractors with operation experience and HSE expert as an advisor. The leader of this HAZOP team is held accountable to record study findings in the HSE MS tool. Therefore the team leader can input HAZOP findings in tool and a user level client. The template is available in the HSE MS tool and in Appendix 3.

The second step in qualitative risk assessment is to assess the hazards identified through HAZOP. Risk Assessment Matrix is globally accepted HSE tool in assessing hazards qualitatively. Risk Assessment Matrix and definition is presented in Appendix 4. The integration of this tool in the HSE MS tool will help depot prove all hazard at ALARP and ensure HSE MS is efficient.

The next steps are to evaluate and implement appropriate measures to reduce or eliminate risks. All the result from the 4 step will be input into HSE MS tool. The interfaces for the 4 steps of qualitative risk assessment are attached in Appendix 5. The result will be stored as Hazard Register. Hazard Register acts as an encyclopedia for hazards at depot. This is the an integral tool in HSE MS. This is because this tool will guide personnel in operations. The Hazard Register is represented according to zonal areas of depot. The Hazard Register consists of the threats/ hazards, effects and consequences, RAM, control, recovery. Therefore personnel can extract info on what precaution measures have been installed and self precautionary steps they must take during operations. The will also understand recovery role the must take in event that the hazard occur. The Hazard Register can also be post at the zone to raise awareness of personnel .Thus, protecting health, safety and environment and achieving goal of HSE MS tool.

Another added HSE tool in HEMP is Bowtie diagram. Bowtie diagram is an alternative representation of Hazard Register. Bowtie diagram concept is represented in figure below:

Figure 13: Bowtie diagram concept



This feature will help user to better understand the Hazard Register. The bowtie diagram is dependent to the Hazard Register. The hazards in Bowtie diagram is represented indeed by hazard classification.

4.3.5 Accident Reports and Investigations

Road Transport is a major part of Shell Malaysia Distribution business. Past track record projects that road transport incidents are a major contributor towards HSE incident statistic for Bagan Luar depot. It is in this consideration that the HSE MS tool includes portion of accident reports and investigation. This feature of HSE MS tool will assist both procedural and performance wise. Haulier and driver are required to submit accident report within 24 hours of incident. This tool will assist this procedure in a sense that submitted reports will be automatically send via e-mail to relevant management personnel. The reports will be stored in database of this tool and can be retrieve for future reference. This will manage data efficiently and lesson learnt from the accident will be optimized.

4.3.6 Emergency Response Preparedness (ERP)

ERP will be activated in the event of major hazard at depot. ERP procedure was developed for operations of this depot. This feature also includes contact numbers for emergency event and ERP exercise schedule. Contact numbers provide personnel reference of who to contact during emergency. ERP exercise is important and it usually includes external parties such as Fire department and medical personnel from nearby hospital. This feature will aid training kit for personnel to prepare for emergency. The ERP exercise schedule can help depot to demonstrate their responsible and action in practicing good HSE practice.

4.3.7 Hazardous Waste

Environmental Quality (Scheduled Waste) Regulations 1989 requires depot to provide information on:

First Schedule - types of wastes generated

Second Schedule - notification of solid wastes

Third Schedule - labelling requirement for scheduled wastes

Fourth Schedule - waste of potential incompatibility

Fifth Schedule - inventory of scheduled waste

Sixth Schedule - consignment note for scheduled wastes

Seventh Schedule - information

This feature of the tool will assist depot operations to comply with DOE requirements. The data submitted into the database of this tool will automatically send to appointed DOE personnel. Waste inventory that have been developed and attached in HSE MS tool is available in Appendix 6.

4.3.8 Audit

The idea of having an audit feature in this tool originated from Shell Malaysia Trading Distribution HSE Advisor. This feature compromises self assessment tool, post audit checklist and audit schedule. Self assessment tool can assist depot to gauge its HSE performance. The assessment tool is contributed by Shell Malaysia Trading Distribution HSE Advisor. Post audit checklist should be done after audit is completed. The developed tool will track audit action items execution. Audit schedule will help depot to be prepared for future audit.

4.3.9 HSE Documents

HSE documents are HSE MS in action. The documents included in this section are Terminal HSE Case, Road Transport HSE Case and HRA Case. Terminal HSE Case is HSE MS in action. It is living proof that hazards are maintained at ALARP. Health Risk Assessment (HRA) is a requirement of MHMS. HRA is the living proof that health hazards are at ALARP. Road Transport HSE Case is the journey management of distributing products to customer.

CHAPTER 5.0
PROBLEMS AND RECOMMENDATIONS

5.1 Problems Encountered

The main problem encountered is communication problem. This project was done on case study basis. Several industries were considered prior to this study. Majority of the depot only replied their answer after sometime. This condition create a major problem due to time constrain. Shell Malaysia Trading Distribution depot at Bagan Luar was chosen as they were the first to respond to proposal of this project. Furthermore, initial communication has been established with them during industrial training. There are various available software that can be incorporated into the HSE MS tool. Few examples are Physical Effect Modeling software and Riskware. These software are not freeware and thus license to use them needs to be obtained at certain monetary cost. This problem is not deemed major as other applicable HSE tools have been incorporated into the HSE MS tool. The development of this tool also requires high IT literacy. Short time frame disable ability to acquire further IT knowledge that could have better this tool.

5.2 Recommendations

This study to develop HSE MS tool has a great commercial potential. There are several recommendations to further enhance this tool or application. The tool is still in Alpha level testing and therefore several future recommendations have been listed. Resources constraint especially in term of time resulting the Alpha version being developed with several enhancement options. The current HSE MS tool is localized to one depot. Future enhance would expand the branch of the tool where several depots are interconnected. The server will be handled by the main headquarters. This enhancement is possible but the WAN should be utilized for this purpose. This added feature will require the tool to utilize Oracle for its information tier.

Future study to improve the current study can focus on assessing whether the intact controls optimize ALARP concept or over do it. This can be conducted using statistical method. Inclusion on HSE software can also increase the marketability of this tool. Quantitative risk assessment of this tool only covers FTA. Future work should concentrate on inclusion of Event Tree Analysis (ETA) and Physical Effect Modeling. Inclusion of these two tools will make quantitative risk assessment of HSE MS tool more comprehensive. The current tool also practice HSE MS tool more manually. Computer programming can be manipulated to generate the HSE elements in HSE MS tool using less human participation. One example is to make RAM selection just by clicking array rather than input of data. Attachment of HSE software will definitely add commercial value to this tool.

There can also be virtual simulation of emergency response plan and also terminal activities by adding multimedia characteristic. This enhancement will require the tool to use Macromedia Flash application as a more domain interface application in client tier. Microsoft Access database must also be supported by Oracle to store database of probable scenarios for simulation. Security aspect can also be enhanced through computer network management security knowledge. The current system only offer login as means to secure data. Scripting can further maximize data security.

CHAPTER 6.0
CONCLUSION

HSE is a compulsory aspect to be considered in any industry and even process for that matter. Various accidents and disasters have occurred due to negligence of HSE aspect. Few of the major ones are the Alpha Piper incident, Union Charbide Bhopal incident and the Longford incident The implementation of HSE MS as structured set of controls for managing HSE; will ensure and to demonstrate the HSE objectives set in the policy are met. HSE MS will also ensure business is legitimate and comply with law and regulations. This study will further evolve HSE MS by producing it as a tool that is easily navigate and execute using desktop computers. This tool should be marketable as it will be utilize in Shell Malaysia Trading depot at Bagan Luar, Penang.

This project is on schedule based on time frame set during the preliminary report. The HSSE MS tool will be developed using a three tier application model using tools – Dreamweaver, IIS, ASP and Microsoft Access. Shell Malaysia Trading Distribution has agreed to collaborate in this project and its HSSE Advisor has finalized the HSE MS tool model. The identified facility to be the pioneer in applying this tool is Bagan Luar depot in Penang. Therefore the development of this tool is based on the depot's operations.

Optimization of resources through project planning and collaboration with industrial practitioners is the key in ensuring this study is feasible and practicable. The end product should be the development of HSE MS tool that is applicable for the industry that participated during the study. This tool will be developed using identified tools and can be applied on desktop computers. Therefore, proving this study is a feasible and marketable effort.

REFERENCES

1. www.sciencedirect.com

2. East Zone Distribution Consultant, Jan 2003, ASEAN+ Distribution HSSE MS Framework Manual.

3. Deitel and Deitel and Nieto, 2nd Edition, 2002, Internet and World Wide Web: How to Program, Prentice Hall.

4. Wells, Geoff,1997, Major Hazards and Their Management, Institution of Chemicals Engineers, UK.

5. Shell Malaysia Trading, Sept 1998, Shell Malaysia Oil Product HSSE MS Manual.

6. E. J. Henley and H. Kumamoto, Prentice-Hall Inc, Englewood Cliffs, Reliability Engineering and Risk Assessment.

7. EN/074, Hazard Identification and Assessment, Shell Expro.

8. EA/032, Escape, Refuge, Evacuation and Rescue - Offshore Installations, Shell Expro.

9. EP 95-0300, Overview Hazards and Effects Management Process HSE Manual, Shell EP.

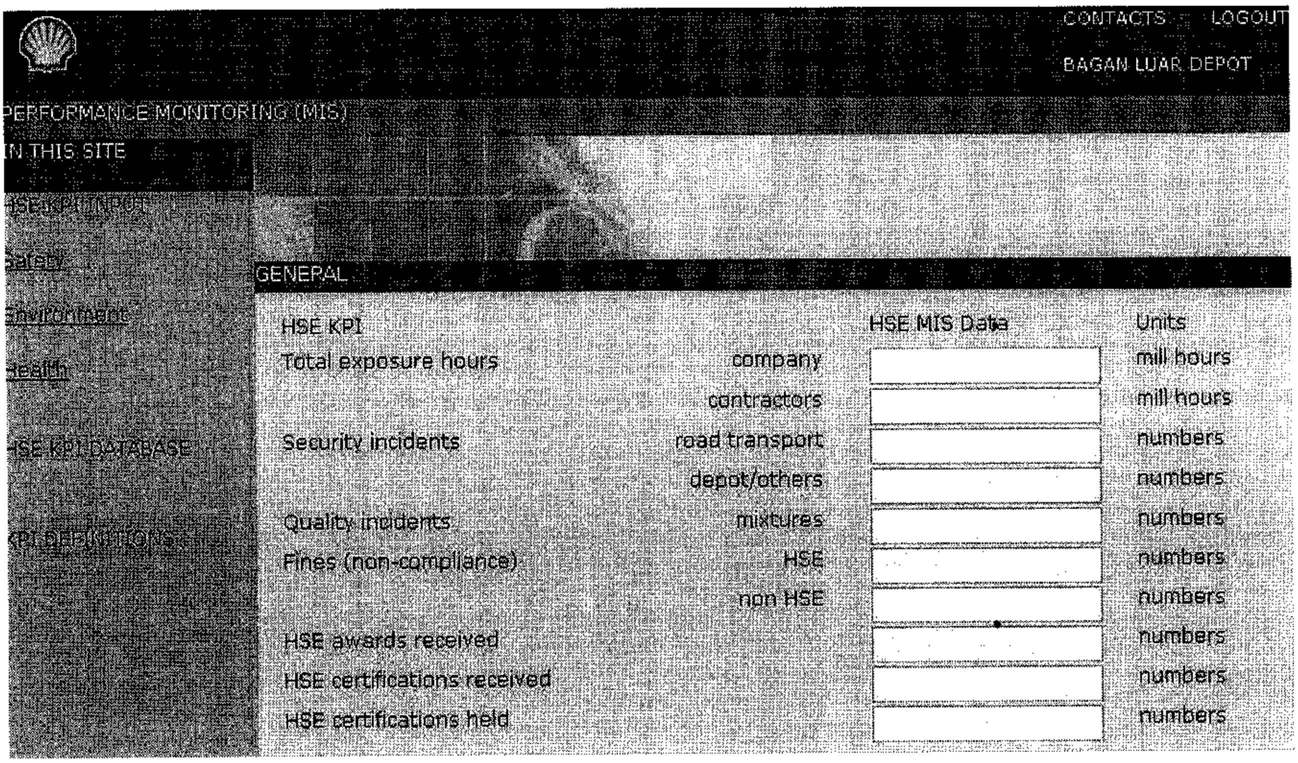
APPENDIX 1: PROJECT TIME FRAME

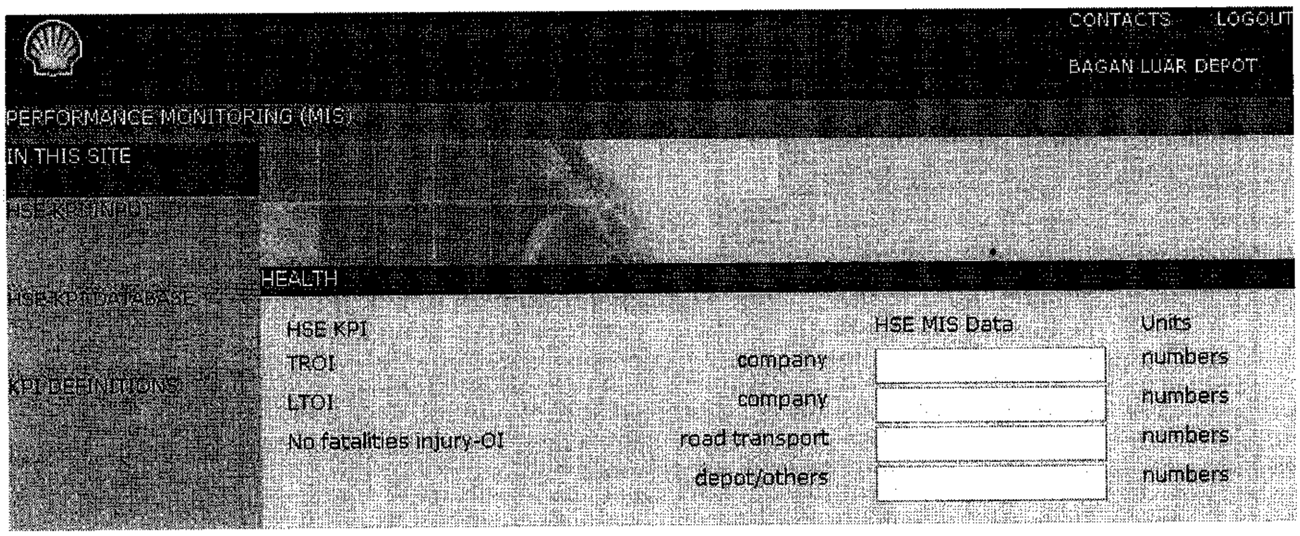
No	Detail / Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Selection of Project Topic	■													
	-propose topic														
	-topic assigned to student														
2	Consultation with supervisor	■	■	■	■	■	■	■	■	■	■	■	■	■	■
3	Project Planning	■	■												
4	Literature Study	■	■												
5	Initiate contact with industrial practitioners		■	■	■										
	-identify alternative facility for case study														
6	Submission of Preliminary Report			o											
	-draft			o											
	-actual report			o											
7	Project Work				■	■	■	■							
	-identified facility for case study														
	-learn identified tools.														
	-development study on HSE MS														
	-design HSE MS tool														
	-feedback/response from industrial practitioners														
8	Submission of Progress Report								o						
9	Project work continue								■	■	■	■			
	-finalize and execute HSE MS tool														
	-feedback/response from industrial practitioners														
10	Submission of Dissertation Final Draft												o		
11	Oral Presentation													o	
12	Submission of Project Dissertation														o

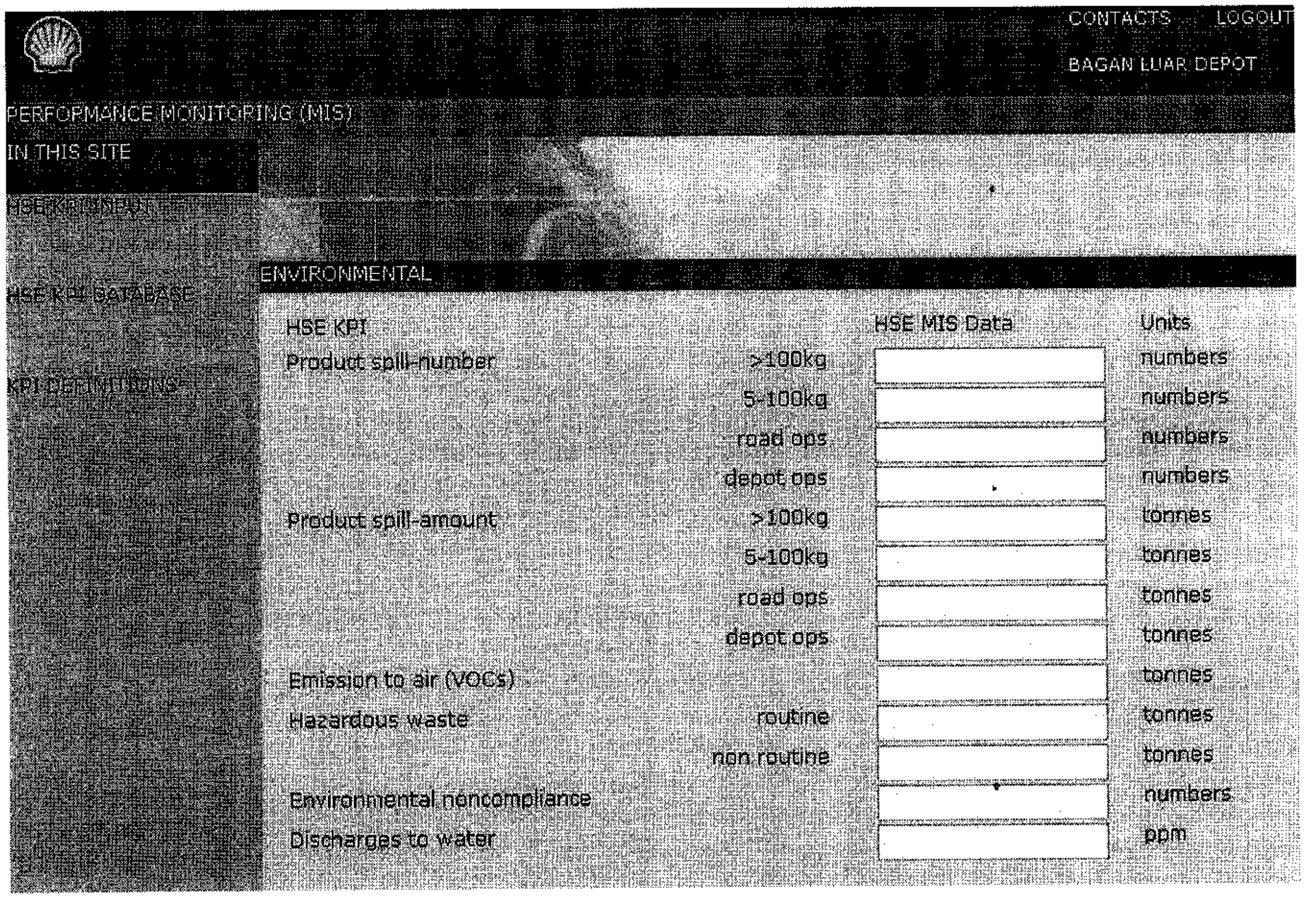
■ Process

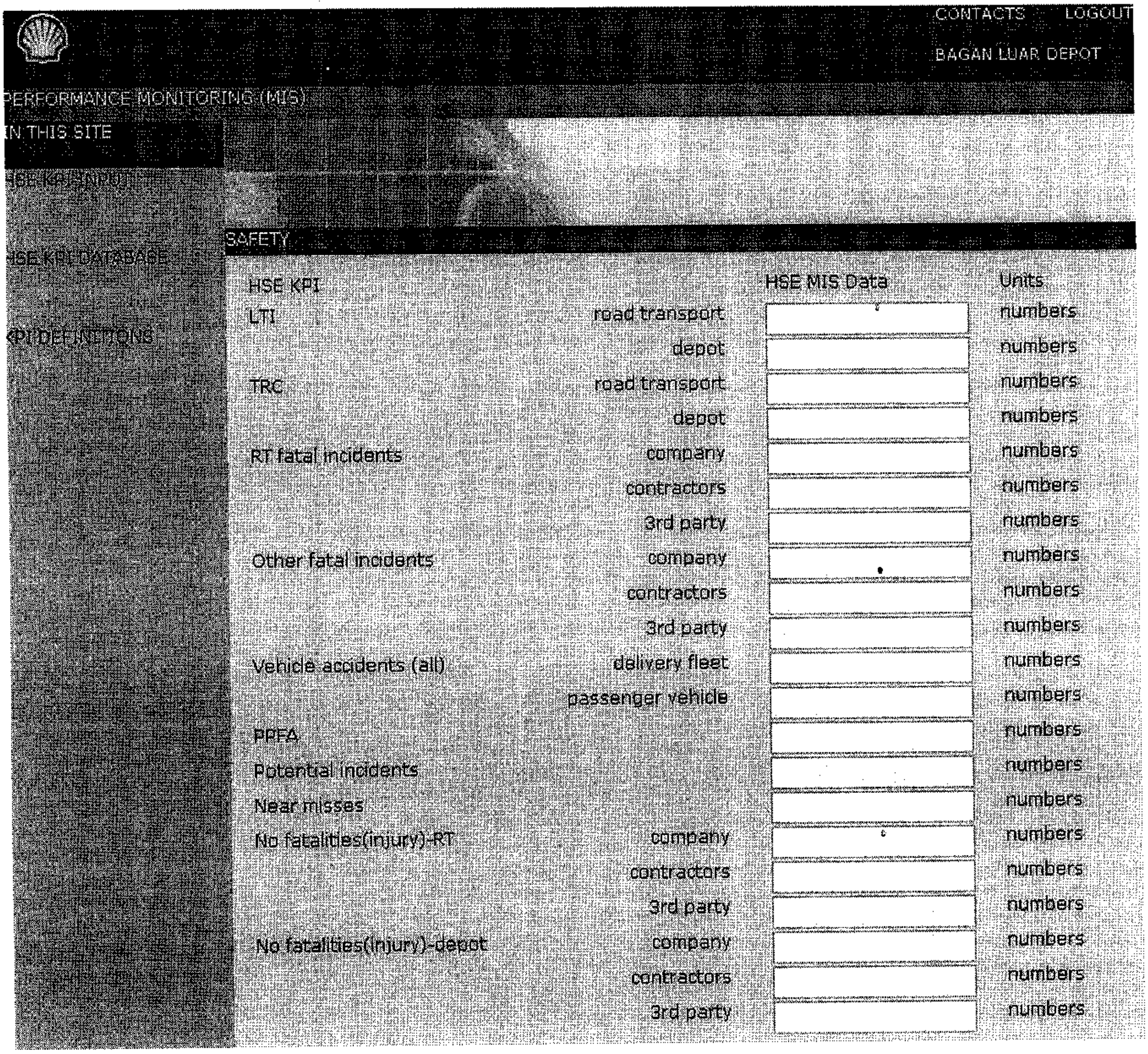
o Milestone

APPENDIX 2 – MANAGEMENT INFORMATION SYSTEM (MIS)






CONTACTS
LOGOUT
BAGAN LUAR DEPOT
PERFORMANCE MONITORING (MIS)
IN THIS SITE
HSE KPI DATABASE
KPI DEFINITIONS
ENVIRONMENTAL
HSE KPI
HSE MIS Data
Units
Product spill-number
>100kg
numbers
5-100kg
numbers
road ops
numbers
depot ops
numbers
Product spill-amount
>100kg
tonnes
5-100kg
tonnes
road ops
tonnes
depot ops
tonnes
Emission to air (VOCs)
tonnes
Hazardous waste
routine
tonnes
non routine
tonnes
Environmental noncompliance
numbers
Discharges to water
ppm



CONTACTS LOGOUT
BAGAN LUAR DEPOT
PERFORMANCE MONITORING (MIS)
IN THIS SITE
HSE KPI INPUT
HSE KPI DATABASE
KPI DEFINITIONS

SAFETY

HSE KPI		HSE MIS Data	Units
LTI	road transport		numbers
	depot		numbers
TRC	road transport		numbers
	depot		numbers
RT fatal incidents	company		numbers
	contractors		numbers
	3rd party		numbers
Other fatal incidents	company		numbers
	contractors		numbers
	3rd party		numbers
Vehicle accidents (all)	delivery fleet		numbers
	passenger vehicle		numbers
PPFA			numbers
Potential incidents			numbers
Near misses			numbers
No fatalities(injury)-RT	company		numbers
	contractors		numbers
	3rd party		numbers
No fatalities(injury)-depot	company		numbers
	contractors		numbers
	3rd party		numbers

APPENDIX 3 – HAZOP RECORDING TEMPLATE

Project:		Date:		Leader :	
Design Intent:		PRESENT:			
Drawing No:					
Line No:	Various	Hazop No:			

Hazop Actions Complete	Sign	Indicator	Date
Hazop Leader:			
Process Area/Department Manager			

Number	Item	Deviation	Possible Causes	Consequences	Safeguards	Action Required	Actionee	By	Closeout Comments

APPENDIX 4: RISK ASSESSMENT MATRIX ABD DEFINITIONS

The Risk Matrix For Worksite HSE Case

Consequence					Increasing Probability →				
					A	B	C	D	E
Rating	People	Assets	Environment	Reputation	Not heard of in the O & G industry in the last 5 years	Heard of Incident in the O&G Industry in the last 5 years	Has occurred in the Company in the last 3 years	Has occurred in the Company in the last 12 months	Has occurred several times per year at location
0	No Injury	No Damage	No Effect	No Impact					
1	Slight Injury	Slight Damage	Slight Effect	Slight Impact		Low			
2	Minor Injury	Minor Damage	Minor Effect	Limited Impact					
3	Major Injury	Localized Damage	Localized Effect	Considerable Impact		Low SB			
4	Single Fatality	Major Damage	Major Effect	Major National		Medium			
5	Multiple Fatalities	Extensive Damage	Massive Effect	Major International					

The Risk Matrix For Worksite HSE Case

The following tables define the consequences:

People

Rating	Potential Impact	Definition
0	No Injury	No injury or damage to health
1	Slight Injury	Not detrimental to individual employability or to the performance of present work
2	Minor Injury	Detrimental to the performance of present work, such as curtailment of activities or some day's of absence to recover, up to a maximum of one week
3	Major Injury	Leading to permanent partial disablement or unfitness to work or detrimental to performance of work over an extended period, such as long term absence
4	Single Fatality	Single fatality or victim with permanent total disability or unfitness for work. Also includes the possibility of multiple fatalities (maximum of 3) in close succession due to the incident, e.g. explosion
5	Multiple Fatalities	May include four fatalities in close succession due to the incident, or multiple fatalities (four or more) each at different points and/or with different activities

Definition of Risk To People

Assets

Rating	Potential Impact	Definition
0	No Damage	No damage to equipment or asset
1	Slight Damage	No disruption to the process. Minimum cost of repair. (Estimated cost of below RM12.5K)
2	Minor Damage	Possible brief disruption to the process. Isolation of equipment for repair. (Estimated cost between RM12.5 K to RM125K)
3	Localized Damage	Plant partly down. Process can (possible) be re-started. (Estimated cost of repair between RM125K to RM1.25M)
4	Major Damage	Partial loss of plant. Plant shut down for at most 2 weeks. (Estimated cost of repair between RM1.25M to RM12.5M)
5	Extensive Damage	Total loss of plant. Extensive damage. (Estimated cost of repair/replacement > RM12.5M)

Definition of Risk To Asset

Environment

Rating	Potential Impact	Definition	Sensitive Areas	Other Areas
0	No Effect	No financial consequences. No environmental risk.	0 liters	0 liters
1	Slight Effect	Slight financial consequences. Local env. damage within the fence and system	< 10 liters	< 100 liters
2	Minor Effect	Contamination. Damage sufficiently large to effect the environment. Single exceedance of statutory / prescribed criteria. Single compliant. No permanent effect on the environment.	10-100 liters	100-1,000 liters
3	Localized Effect	Limited loss of discharge of known toxicity. Repeatedly exceeding statutory or prescribed limits and beyond fence or neighborhood.	100-1,000 liters	1,000-10,000 liters
4	Major Effect	Severe environmental damage. The OPCO is required to take extensive measures to restore the contaminated environment to its original state. Extended exceedance of statutory or prescribed limits.	1,000-10,000 liters	10,000 - 100,000 liters
5	Massive Effect	Persistent severe environmental damage or severe nuisance extending over a large area. In terms of commercial or recreational use or nature conservancy, a major economic loss for the OPCO. Constant, high exceedance of statutory or prescribed limits.	> 10,000 liters	> 100,000 liters

Examples of sensitive areas are areas such as beaches, marine life breeding ground, catchment areas, water-front villages, forest reserves, upstream of rivers, parks, residential areas etc.

Definition of Risk To Environment

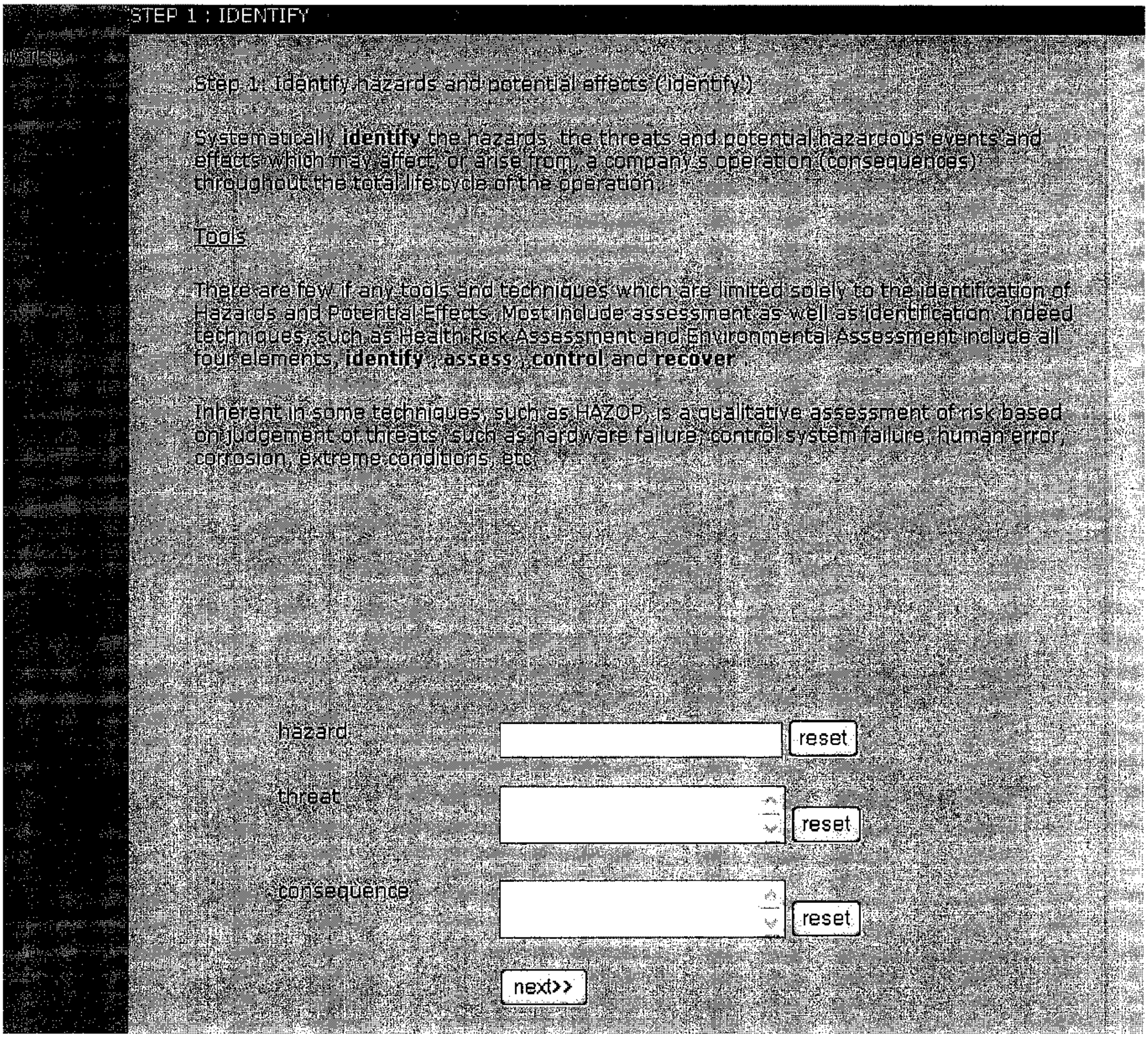
Reputation

Rating	Potential Impact	Definition
0	No Impact	No public awareness
1	Slight Impact	Public awareness of the incident may exist. There is no public concern
2	Limited Impact	Some local public concern. Some complaints received. Slight local media and/or political attention with potentially negative impact for OPCO operations.

3	Considerable Impact	Regional public concern. Numerous complaints. Extensive negative attention in local media. Slight national media and/or local/regional political attention with possible negative stance of local government and/or action groups.
4	National Impact	National public concern. Continuing complaints. Extensive negative attention in the national media and/or regional/national policies with potentially restrictive measures and/or impact on grant of licenses. Mobilization of action groups.
5	International Impact	International public attention. Extensive negative attention in international media and national/international politics. Potential to harm access to new areas, grant of licenses and/or tax legislation. Concerted effort by action groups. Adverse effects.

Definition of Risk To Reputation

APPENDIX 5 – HEMP – QUALITATIVE RISK ASSESSMENT



STEP 2 : ASSESS

STEP

Step 2: Evaluate risks

Systematically evaluate (**assess**) the risks from the identified hazards against accepted screening criteria, taking into account the likelihood of occurrence and the severity of any consequences to employees, assets, the environment and the public. This includes the risks associated with deviation from limits set for environmental and occupational health hazards.

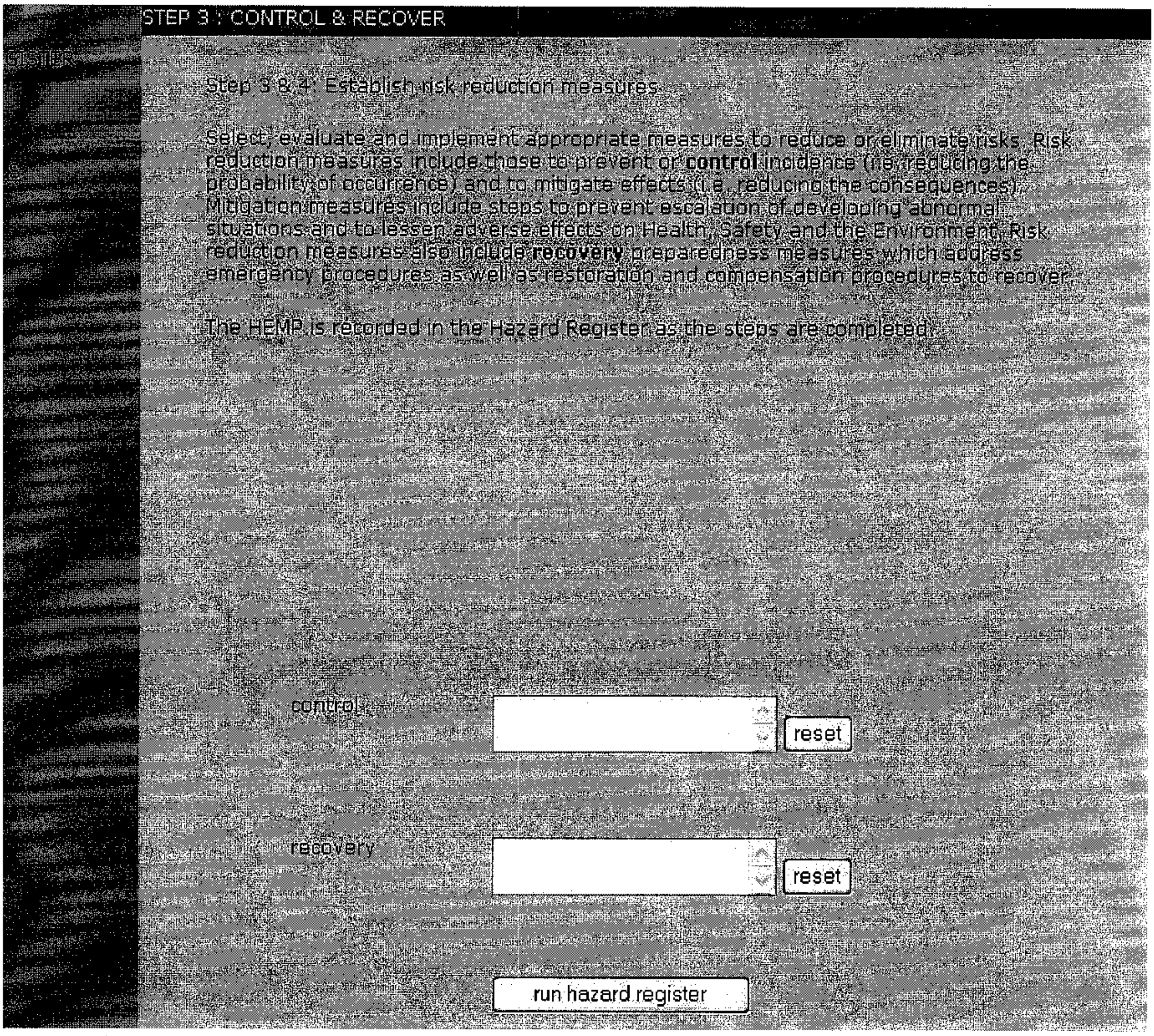
It is possible to represent the risk graphically using the Risk Assessment Matrix (RAM) The matrix need not remain as a static display of risk and measures to be taken. Over the years tolerance to risk will change therefore the shading in the diagram will change.

Quantitative Risk Assessment (QRA) provides a structured approach to assessing risk and expresses this numerically. The main function of QRA is to identify high risk areas and assist in the comparison of design options and the selection of operations philosophies with a view to establishing effective and efficient risk management.

QRA and RAM assists in the determination of 'how safe is safe enough' by helping to analyse options to establish whether or not ALARP (As Low As Reasonably Practicable) has been achieved.

risk matrix reset

next>>


STEP 3 : CONTROL & RECOVER
Step 3 & 4: Establish risk reduction measures
Select, evaluate and implement appropriate measures to reduce or eliminate risks. Risk reduction measures include those to prevent or control incidence (i.e. reducing the probability of occurrence) and to mitigate effects (i.e. reducing the consequences). Mitigation measures include steps to prevent escalation of developing abnormal situations and to lessen adverse effects on Health, Safety and the Environment. Risk reduction measures also include recovery preparedness measures which address emergency procedures as well as restoration and compensation procedures to recover.
The HEMP is recorded in the Hazard Register as the steps are completed.
control
reset
recovery
reset
run hazard register

APPENDIX 6: HAZARDOUS WASTES INVENTORY